DOCUMENT RESUME

ED 160 861 CE 018 201

TITLE	Radioman 3&2. (Revised).
INSTITUTION	Naval Education and Training Program Development Center, Pensacola, Fla.
SPONS AGENCY	Naval Education and Training Command, Washington, D.C.
REPORT NO	NAVEDTRA-10228-G
PUB DATE	78
NOTE	559p.; Parts may be marginally legible due to small type
AVAILABLE FROM	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (Stock Number 0502-LP-051-1410)
EDRS PRICE	MF-$1.00 HC-$30.13 Plus Postage.
DESCRIPTORS	Armed Forces; Autoinstructional Aids; Electricity; Emergency Programs; *Independent Study; Learning Modules; Military Personnel; *Military Training; Navigation; Performance Based Education; Promotion (Occupational); *Radio Technology; *Technical Education; Telecommunication; Test Wiseness
IDENTIFIERS	*Navy; *Radiomen

ABSTRACT

This Rate Training Manual and Nonresident Career Course (RTM/NRCC) form a self-study package that will enable Navy radiomen to help themselves to fulfill the requirements of their rating. Of the seventeen chapters in the manual, the first is nontechnical, providing information concerning the radioman rating and the Navy advancement system and helpful hints for preparing for Navy examinations. The remaining sixteen chapters deal with the technical requirements of the rating which include the subjects of basic electricity; transmitter, receiver, and antenna theory; types and theory of radio wave propagation; systems of diagnosis and quality assurance; testing equipment; communications organization, security, and message formats; theory and operation of teletypewriter circuits, automated systems, and radio communications equipment; procedures of fleet communications and distress communications; and classes and types of commercial traffic. The manual's appendix furnishes a glossary of terms, electronics symbols, and basic electrical formulas. Using the manual as its textbook, the NRCC contains a set of assignments consisting of multiple choice questions and self-scoring answer sheets. The learning objectives which precede each assignment set are designed to lead students through the RTM. (ELG)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED160861

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

RADIOMAN 3&2

CE

NAVAL EDUCATION AND TRAINING COMMAND
RATE TRAINING MANUAL AND NONRESIDENT CAREER COURSE

NAVEDTRA 10228-G

CE 018 201

Although the words "he", "him", and "his", are used sparingly in this manual to enhance communication, they are not intended to be gender driven nor to affront or discriminate against anyone reading *Radioman 3 & 2*, NAVEDTRA 10228-G.

PREFACE

This Rate Training Manual and Nonresident Career Course (RTM/NRCC) form a self-study package that will enable ambitious Radiomen to help themselves fulfill the requirements of their rating. Among these requirements are to understand basic electricity and transmitter, receiver, and antenna theory; ensure quality assurance utilizing test equipment; and possess a basic knowledge of communications organization, security, message formats, and procedures of fleet communications.

Designed for individual study and not formal classroom instruction, the RTM provides subject matter that relates directly to the occupational standards of the Radioman rating as listed in the Manual of Manpower and Personnel Classifications and Occupational Standards, NAVPERS 18068D. The NRCC provides the usual way of satisfying the requirements for completing the RTM. The set of assignments in the NRCC includes learning objectives and supporting items designed to lead students through the RTM.

Those who work in communications know how fast procedures and equipment change. Between revisions of this training manual, some obsolescence may be unavoidable. For this reason, it is suggested that the student with access to official communication publications use them as much as possible while studying for advancement.

This training manual and nonresident career course were prepared by the Naval Education and Training Program Development Center, Pensacola, Florida, for the Chief of Naval Education and Training. Technical assistance was provided by the Commander, Naval Telecommunications Command, Washington, D.C., and the Radioman "C" School, Service School Command, Naval Training Center, San Diego, California.

Revised 1978

Stock Ordering No.
0502-LP-051-1410

Published by
NAVAL EDUCATION AND TRAINING SUPPORT COMMAND

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON, D.C.: 1978

4

THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

CONTENTS

Chapter Page

1. Training and Advancement 1
2. Basic Electricity 14
3. Basic Transmitter Theory 60
4. Basic Receiver Theory 78
5. Basic Antenna Theory 88
6. Radio Wave Propagation 100
7. Basic Test Equipment 116
8. Systems Diagnosis and Quality Assurance 146
9. Communications Organization 182
10. Communications Security 198
11. Basic Message Format 215
12. Radiotelephone Procedures 248
13. Manual Teletypewriter Procedures 274
14. Automated Systems 293
15. Fleet Communications 323
16. Distress Communications 350
17. Commercial Traffic 357

APPENDIX

I. Glossary of Terms 378
II. Electronics Symbols 384
III. Basic Electrical Formulas 391

INDEX 392

Nonresident Career Course follows Index

6

CREDITS

The illustration indicated below is included in this edition of Radioman 3 & 2 through the courtesy of the designated source. Permission to reproduce this illustration must be obtained from the original source.

Source	Figure
Automatic Electric Company	14-17

CHAPTER 1

TRAINING AND ADVANCEMENT

In the performance of his duties, the Radioman acts as the direct representative of his commanding officer to provide the command with the capability of exchanging accurate, rapid, and secure information with other commands. To become and remain effective, the Radioman must be familiar with the tasks at hand and the communications capabilities available.

It is the purpose of this rate training manual to provide the necessary training to develop your knowledge of the professional or occupational standards of the Radioman rating. There are 17 chapters in this manual. The first chapter is nontechnical in nature. The remaining chapters deal with the technical aspects of the Radioman rating. The introductory chapter provides information concerning the Radioman rating, the advancement system in the Navy, and helpful tips about preparing for Navywide examinations. Study this chapter prior to beginning intensive study of the remaining chapters.

THE RADIOMAN RATING

Your responsibilities as a petty officer in the Radioman rating include two types of duties: Professional duties and military duties.

PROFESSIONAL DUTIES

Your professional duties as a Radioman third or second class will vary depending on the type and mission of your command. If you are stationed ashore, you will normally be assigned to the communications center or a communications station. Here, your job will be concerned primarily with sending, receiving, and processing message traffic. The handling of this message traffic may be in support of your command only or of an entire naval base complex with numerous commands. If you are stationed afloat, your duties may include a wide variety of responsibilities. The scope of these assignments may run from setting up and operating radioteletype circuits, including cryptographic equipment, to publication corrections and message distribution.

As a Radioman, you are primarily an operator. As such, you will be required to fulfill certain qualifications that require you to know what makes your equipment work as well as how to operate it.

Yours is an ever-changing and challenging rating. The Navy is constantly developing new and more sophisticated communications equipment promoting a more effective "voice of command."

MILITARY DUTIES

Often, the difference between a "good" petty officer and a "bad" petty officer is leadership. Each command should have a training program that provides instruction in leadership principles and practices. The individual who wants to move ahead takes advantage of this instruction. He applies its principles and practices in his every dealing with the personnel around him—especially those who look to him for an example of leadership.

Many books have been written on the subject of leadership, and many traits have been listed as a necessary part of the makeup of a leader. Whether or not you are a successful leader is indicated by the success with which you stimulate others to work willingly under your supervision.

Self-confidence is one of the keys of leadership, but it must be backed up by enthusiasm, understanding of others, and especially by knowledge. For example, you not only must be able to supervise and teach lower rated personnel in their communication duties, but you must be ready to pitch in and help complete the job. Your personnel will respect you as an individual who has demonstrated his knowledge and skill.

A cooperative attitude is another requirement of leadership. Do not let your experience in the Radioman rating make you unreasonable and overbearing with the lower rated personnel. Your attitudes will have a definite influence upon their attitudes and actions.

When you become a petty officer, you become a link in the chain of command between your officers and your personnel. Your responsibilities are more than merely giving orders and seeing that work is done. You also have a responsibility for sharing your knowledge with others. When the Navy promotes you, it expects you to train other personnel. Always stand ready to pass on your knowledge of new equipment and procedures to others.

A petty officer's working relationship with others is of great importance to the success of his work and the mission of his command. Your day-to-day working relationships will be most successful as you cooperate with others, both within and outside your own division or department. The ability to get along is, at times, just as necessary as proficiency in performing your technical skills. The ability to work with others is a definite skill. This skill can be developed in much the same manner that you develop a technical skill. The many different skills you need may each be studied and developed. Some of these skills are understanding another individual's job, his problems, and his abilities. Others are instructing, leading, and inspiring the men and women with whom you work.

THE NAVY ADVANCEMENT SYSTEM

Many of the rewards of Navy life are earned through the advancement system. Some of these rewards are easy to see. You get more pay. Your job assignments become more interesting and challenging. You are regarded with greater respect by officers and enlisted personnel. You enjoy the satisfaction of getting ahead in your chosen Navy career.

But the advantages are not yours alone. The Navy also profits. Highly trained personnel are essential to the functioning of the Navy. By each advancement, you increase your value to the Navy in two ways. First, you become more valuable as a specialist in your rating, and second, you become more valuable as a person who can train others and, thus, make far-reaching contributions to the entire Navy.

The basic ideas behind the advancement system have remained stable for many years, but specific portions may change rapidly. It is important that you know the system and follow changes carefully. BUPERS NOTICE 1418 will keep you up-to-date. Ask your educational services officer to let you read the latest copy of the 1418. This notice is usually published four times a year. The June notice covers the petty officers third, second, and first class for the September examination. The August notice covers the senior and master chief petty officer examination information for the November examination. Two 1418 notices are published in November for the E-7 examination in January and the E-6, E-5, and E-4 examinations in March.

The normal system of advancement may be easier to understand if it is divided into two parts:

1. Those requirements that must be met before you are qualified, that is, considered for advancement.
2. Those factors that actually determine whether or not you will be advanced.

Navy training and advancements are based on the naval and occupational standards found in the Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards, NAVPERS 18068. This publication, which will be described in detail later in this chapter, establishes the minimum occupational standards for enlisted personnel and identifies those additional skills required in specific billets which are supplemental to rating skill requirements.

HOW TO QUALIFY FOR ADVANCEMENT

In general, to qualify (be considered) for advancement, you must first:

1. Have a certain amount of time in the service.

2. Have a certain amount of time in your present paygrade.

3. Demonstrate knowledge of material in your mandatory rate training manuals by achieving a suitable score on your command's locally prepared and locally administered test, or by successfully completing the appropriate nonresident career courses (NRCCs), or in some cases, by successfully completing an appropriate Navy school.

4. Demonstrate the ability to perform the requirements under the Personnel Advancement Requirement (PAR), NAVPERS 1414/4, program.

5. Pass the Radioman Performance Test.

6. Be recommended by your commanding officer.

7. For petty officer third and second class candidates only, demonstrate knowledge of military subjects by passing a locally administered military leadership examination based on the naval standards for advancement (from NAVPERS 18068).

8. Demonstrate knowledge of the technical aspects of your rating by passing a Navywide advancement examination based on the occupational standards applicable to your rating (from NAVPERS 18068, those standards listed at and below your rate level).

Figure 1-1 gives a detailed view of the requirements for advancement of active duty personnel; figure 1-2 gives this information for inactive duty personnel. Remember that the occupational standards can change. Check with your educational services officer to be sure that you know the most recent standards.

If you meet all the preceding requirements, you become a member of the group from which selections for advancement are made.

FACTORS WHICH AFFECT ADVANCEMENT

Advancement is not automatic. Even though you have met all the requirements, including passing the written examinations, you may not be able to "sew on the crow" or "add a stripe." The number of personnel in each rate and rating is controlled on a Navywide basis. Therefore, the number that may be advanced is limited by the number of vacancies that exist. When the number passing the examination exceeds the number of vacancies, some system must be used to determine who may be advanced and who may not. The system used is the "final multiple" and is a combination of three factors:

Performance

Examinations

Longevity, or seniority

The Navy's system provides credit for performance, knowledge, and seniority, and, while it cannot guarantee that any one person will be advanced, it does guarantee that all within a particular rating will have equal advancement opportunity.

Who Will Be Advanced?

Advancement to PO3, PO2, and PO1 is based on quota limitations, as determined by the Chief of Naval Personnel, and highest "final multiple." The final multiple is a combination of your beginning multiple and exam score. The beginning multiple consists of the following elements:

1. Performance factor—These points are based on the average of your performance evaluations for a given period of time before the exam is given. The period of time used varies with the paygrade to which you are seeking advancement. If you are seeking advancement to PO3, your evaluations for the past months will be averaged; the maximum number of points for performance is 70.

2. Length of service—Points for length of service are determined by subtracting the number of years you have served in your present paygrade from the number of years you have been serving on active naval service, and adding 15. Thus, an E-4 with 4 years in service and 1 year in paygrade would have 18 points (4 years in service minus 1 year in rate = 3 plus 15 = 18). The maximum number of points possible for length of service is 30.

3. Time in rate—Points for time in rate are computed by multiplying the number of years you have served in your present paygrade by 2 and adding 15 (the E-4 mentioned above would have 1 year in rate times 2 = 2 plus 15 = 17).

4. Awards—Some medals and awards, if you are entitled to them, may be worth points to you. The Manual of Advancement, BUPERSINST 1430.16, contains a list of medals and awards and the number of points assigned to each. The maximum number of points possible for awards for PO3 and PO2 is 10.

5. Passed Not Advanced (PNA)—These points are determined by the Naval Education and Training Program Development Center and are assigned to those personnel who previously passed the exam but were not advanced. For

REQUIREMENTS*	E1 to E2	E2 to E3	#E3 to E4	#E4 to E5	E5 to E6	##†E6 to E7	##†E7 to E8	##†E8 to E9
SERVICE	6 mos. service.	6 mos. as E-2.	6 mos. as E-3. 2 years time in service.	12 mos. as E-4. 3 years time in service.	24 mos. as E-5. 7 years time in service.	36 mos. as E-6. 10 years time in service.	36 mos. as E-7. 8 of 13 years time in service must be enlisted.	36 mos. as E-8. 10 of 16 years time in service must be enlisted.
SCHOOL	Recruit Training. (C.O. may advance up to 10% of graduating class.)		Class A for PR3, DT3, IS3, AME3, HM3, FTB3, MT3, MU3, EW3	Naval Justice School LN2		Navy School for AGC, MUC.††		
PERSONNEL ADVANCEMENT REQUIREMENT (PAR) NAVPERS 1414/4			Personnel Advancement Requirement (PAR) must be completed for advancement to E-4 through E-7.					
PERFORMANCE TEST			Specified ratings must complete applicable performance tests before taking examinations.					
ENLISTED PERFORMANCE EVALUATION	As used by CO when approving advancement.		Counts toward performance factor credit in advancement multiple.					
EXAMINATIONS**	Locally prepared tests.	See below.	Navywide examinations required for all PO advancements.			Navywide selection board.		
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIREMENTS)		Required for E-3 and all PO advancements unless waived because of school completion, but need not be repeated if identical course has already been completed. See NAVEDTRA 10052 (current edition).					Nonresident career courses and recommended reading. See NAVEDTRA 10052 (current edition).	
AUTHORIZATION	Commanding Officer		NAVEDTRAPRODEVCEN					

*All advancements require commanding officer's recommendation.
†2 years obligated service required for E-7, E-8, and E-9.
#Military leadership exam required for E-4 and E-5.
**For E-2 to E-3, NAVEDTRAPRODEVCEN exams or locally prepared tests may be used.
††Waived for qualified EOD personnel.
##Advancement to E-7 will be 10 years TIS effective 1 January 1979; to E-8, 13 years TIS effective 1 November 1978; to E-9, 16 years TIS effective 1 November 1978.

Figure 1-1.—Active duty advancement requirements.

REQUIREMENTS*	E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7	E8	E9
TOTAL TIME IN GRADE	6 mos.	6 mos.	6 mos.	12 mos.	24 mos.	36 mos. with total 9 yrs service.	36 mos. with total 12 yrs service.	24 mos. with total 15 yrs service.
TOTAL TRAINING DUTY IN GRADE†	14 days	14 days	14 days	14 days	28 days	42 days	42 days	28 days
PERFORMANCE TESTS			Specified ratings must complete applicable performance tests before taking examination.					
DRILL PARTICIPATION	Satisfactory participation as a member of a drill unit in accordance with BUPERSINST 5400.42 series.							
PERSONNEL ADVANCEMENT REQUIREMENT (PAR) NAVPERS 1414/4			Personnel Advancement Requirements (PAR) NAVPERS 1414/4 must be completed for advancement to E4 through E7.					
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIREMENTS)	Completion of applicable course or courses must be entered in service record.							
EXAMINATION	Standard Exam		Standard Exam required for all PO advancements. Also pass Military Leadership Exam for E4 and E5.				Standard Exam Selection Board.	
AUTHORIZATION	Commanding Officer		NAVEDTRAPRODEVCEN					

*Recommendation by commanding officer required for all advancements.
†Active duty periods may be substituted for training duty.

Figure 1-2.—Inactive duty advancement requirements.

advancement to PO3 and PO2, the maximum number of PNA points possible is 10. Figure 1-3 is an example of all the elements that can make a final multiple.

The exams are scored, multiple factors are added, and a listing from highest to lowest final multiple scores is prepared for each rate. Since advancement to E-4, E-5, and E-6 is based on quota limitations, the selections are made from the top of the list down as far as quota limitations allow. This process identifies those who will be advanced. Listings are then prepared for each command listing those who will be advanced, those who passed but will not be advanced, and those who failed.

HOW TO PREPARE FOR ADVANCEMENT

You must study the occupational standards, work on the Personnel Advancement Requirement (PAR) and the Personnel Qualification Standards (PQS), and study the required rate training manuals and other material that is required for advancement in your rating. The following sections describe the publications you should be familiar with and give practical suggestions on how to use them in preparing for advancement.

	POINTS
PERFORMANCE FACTOR: (based on performance evaluation average)	60
LENGTH OF SERVICE: (4 yrs in service minus 1 yr in grade, plus 15)	18
TIME IN RATE: (1 yr in rate times 2 plus 15)	17
AWARDS: (1 Good Conduct Medal)	02
PASSED NOT ADVANCED: (As assigned by Naval Education and Training Program Development Center)	01
TOTAL BEGINNING MULTIPLE:	98
EXAM STANDARD SCORE:	68
FINAL MULTIPLE:	166

Figure 1-3.—Computation of Final Multiple.

The Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards, NAVPERS 18068

NAVPERS 18068 contains the occupational and naval standards for advancement to each paygrade. It consists of two sections. Section I describes the Naval Standards and Occupational Standards. Section II contains the Navy Enlisted Classifications (NEC). While the occupational standards manual defines only the minimum skills required for your rating, there are knowledge factors inherent in these skills. It is kept current by means of changes.

Naval standards are expressed as minimum skills that apply to all ratings rather than to any one rating. Naval requirements for advancement to third class and second class petty officer rates deal with military conduct, naval organization, military justice, security, watchstanding, and other subjects which are required of petty officers in all ratings.

Occupational standards define enlisted tasks required of personnel within a particular rate or rating and are divided into subject matter groups.

If you are working for advancement, you should remember that you are responsible for the occupational standards applicable to the rating you are taking the examination for and to the standards of the lower paygrade(s) in the rating. An E-5 candidate is responsible for E-5 and E-4 standards; an E-6 candidate for E-6, E-5, and E-4 standards; and an E-7 candidate for E-7, E-6, E-5, and E-4 standards.

Personnel Advancement Requirement (PAR), NAVPERS 1414/4

One of the requirements to determine eligibility for advancement is the completion of the PARs for your rating. The purpose of the PAR is to: (1) individualize advancement requirements for each rating and for rates within the rating and (2) provide a Consolidated Checklist that individuals can use in their evaluation of the individual in determining readiness for advancement. It can provide a record of progress toward, and a history of, advancement.

PAR is designed as a checklist of the various minimum requirements for advancement. It is presented in three sections:

Section I, Administration Requirements, contains the individual's length of service, time in paygrade, and a checkoff entry to show the individual has passed the E-4/E-5 military leadership examination.

Section II, Formal School and Training Requirements, contains a checkoff entry to show the individual has completed the applicable Navy military requirements and rate training courses.

Section III, Occupational and Military Ability Requirements, is a checkoff list of task statements. Items demand actual demonstration of the item or completion of an alternate local examination, although demonstration is a command prerogative. Individuals are evaluated on their ability to perform a specific task, whether it be by observation, by training received, or, if desired, by demonstration.

PARs for all ratings are listed in the Navy Stock List of Publications and Forms, Section I, NAVSUP Publication 2002. Ask your educational services officer for a copy of the PAR for your rating.

The E-8 and E-9 paygrades are exempt from the program because there are other means of selection for advancement to these paygrades. Also, the E-3 apprenticeships are so broad that it is impractical to develop a single PAR for this paygrade.

The PAR form for each rating lists the requirements for advancement to paygrades E-4 through E-7 in one pamphlet.

Personnel Qualification Standards, NAVEDTRA 43100.1 (series)

The Personnel Qualification Standards (PQS) program is another element in the Navy's overall training program. It is used to help develop in each person the skills necessary to perform his assigned duties.

The Handbook on Management and Implementation Procedures for Personnel Qualification Standards, NAVEDTRA 43100.1 (series), provides information on the PQS concept and describes its implementation into the training program of operational units of the Navy.

The purpose of the program is to assist in qualifying the trainee to perform his duties. It is recommended that each trainee carry his qualification card so he can take advantage of training "targets of opportunity" that may occur during the daily routine. The individual is allowed to progress at a pace that fits his individual learning ability. This, of course, is contingent upon time periods established by department heads and division officers. The personnel qualification standards program helps to prepare personnel for advancement. When studying the answer theory questions, the trainee is referred to applicable rate training manuals.

To determine what equipment or watchstation is in the personnel qualification standards program and to obtain the stock number for a particular personnel qualification standards booklet, refer to the latest edition of the List of Training Manuals and Correspondence Courses, NAVEDTRA 10061.

Each qualification standard has four main subdivisions in addition to a preface and introduction, glossary, bibliography, and feedback form. They are as follows:

100 Series—Theory
200 Series—System
300 Series—Watchstations (duties, assignments, or responsibilities)
400 Series—Qualification cards

The introduction explains the use of the qualification standards in terms of what it will mean to the user as well as how to apply it.

The theory (100 Series) section specifies the knowledge of theory necessary as a prerequisite to the study of the specific equipment or system for which the PQS was written. These fundamentals are normally taught in the formal school (for example, Class A School) phase of an individual's training. However, if the individual has not been to school, the requirements are outlined and references are cited which will provide guidelines for a self-study program.

The system (200 Series) section breaks down the equipment or systems to be studied into functional sections. PQS items are constructed as clear, concise statements/questions according to a standard format. The answers must be extracted from the various maintenance manuals covering the equipment or systems for which the PQS is written. This section asks the user to explain the function of the system, to draw a simplified version of the system from memory, and to use this drawn schematic or the schematic provided in the maintenance manual while studying the system or equipment. Emphasis is given to such areas as maintenance management procedures, components, component parts, principles of operation, system interrelations, numerical values considered necessary to operation and maintenance, and safety precautions. A study of the items in the system section provides the individual with the required information concerning what the system or equipment does, how it does it, and other pertinent aspects of operation.

The watchstations (300 Series) section includes questions regarding the procedures the individual must know to operate and maintain the equipment or system. In this section, the questions advance the qualification process by requiring answers or demonstrations evidencing the ability to use the knowledge covered in the system section and to maintain the system or equipment. Areas covered include normal operation; abnormal or emergency operation; emergency procedures which could limit damage and/or casualties associated with a particular operation; operations that occur too frequently to be considered mandatory performance items; and maintenance procedures/instructions such as checks, tests, repair, replacement, etc.

The qualification cards (400 Series) section covers the accounting documents used to record the individual's satisfactory completion of items. A complete PQS package should be given to each person being qualified so that he can use it at every opportunity to become fully qualified in all areas of the appropriate rating and the equipment, system, or watchstation for which the PQS was written. At what point to begin a PQS booklet will depend on the individual's assignment within the activity. Upon transfer to a different activity, each individual must requalify. The answers to the questions asked in the qualification standards may be given orally or in writing to the supervisor, the branch or division officer, and/or the maintenance officer as required to certify proper qualification. The completion of part or all of the PQS provides a basis for the supervising petty officer and officer to certify completion of Personnel Advancement Requirements (PAR).

Bibliography for Advancement Study, NAVEDTRA 10052 (series)

NAVEDTRA 10052 (series) is a very important publication for any enlisted person preparing for advancement. It lists required and recommended rate training manuals and other reference material to be used by personnel studying for advancement.

NAVEDTRA 10052 is revised and issued once each year by the Chief of Naval Education and Training. Each revised edition is identified by a letter following the NAVEDTRA number. When using this publication, be sure that you have the most recent edition.

In using NAVEDTRA 10052, you will notice that some rate training manuals are marked with an asterisk (*). Any manual marked in this way is mandatory, that is, it must be completed before you can be eligible to take the Navywide examination for advancement to the indicated level. Ask your educational services officer how to order these publications.

Do not overlook the section of NAVEDTRA 10052 which lists the required and recommended references relating to the naval standards for advancement. Personnel of all ratings must complete the mandatory military requirements training manual.

Occupational Standards and Bibliography Sheets

For your convenience in preparing for the Navywide examinations, NAVEDTRAPRODEVCEN, Pensacola, FL prepares a separate Occupational Standards and Bibliography Sheet for each rating (RM, EW, ST, etc.). The sheet lists the occupational standards for paygrades E-4 through E-9 for the particular rating, and also lists the recommended study material and specific references from the current edition of the Bibliography for Advancement Study, NAVEDTRA 10052. Ask your educational services officer for a copy of the most recent edition of this sheet.

List of Training Manuals and Correspondence Courses, NAVEDTRA 10061 (series)

NAVEDTRA 10061 is revised and issued once each year by the Chief of Naval Education and Training. Each revised edition is identified by a letter following the NAVEDTRA number. When using this publication, be sure that you have the most recent edition.

This list has been distributed to all ships and stations to inform them of the latest available training manuals and correspondence courses. Ask your educational services officer for this list.

The listings in NAVEDTRA 10061 include a brief overview of the contents of each training manual and correspondence course. All publications with stock ordering numbers listed may be obtained from the Naval Publications and Forms Center, Philadelphia, PA 19120. Use DD Form 1348 for ordering. Some classified publications are issued from the NAVEDTRA-PRODEVCEN, Pensacola, FL 32509. These publications have special ordering requirements, as described in NAVEDTRA 10061.

TRAINING MANUALS

Rate training manuals (RTMs) and nonresident career courses (NRCCs) are prepared as self-study packages to assist personnel of the regular Navy and Naval Reserve in developing the knowledge required for their ratings.

There are two general types of training manuals. Rate training manuals, such as this one, are prepared for most enlisted ratings. A rate training manual provides information that is directly related to the occupational qualifications of ONE rating. SUBJECT MATTER manuals or BASIC manuals, such as Naval Orientation, NAVEDTRA 16138 (series), give information that applies to more than one rating.

BASIC NAVY TRAINING MANUALS

Among the most important sources of information are the basic Navy training manuals. These manuals cover broad subject areas which are common to many ratings. The material contained in some of these courses will make your rate training manual easier to understand.

RATE TRAINING MANUALS

Rate training manuals are revised from time to time to keep them up-to-date. The revision of a rate training manual is identified by a letter following the NAVEDTRA number (NAVEDTRA 10052-Z). You can tell whether any particular copy of a training manual is the latest edition by checking the NAVEDTRA number and the letter following this number in the most recent edition of the List of Training Manuals and Correspondence Courses, NAVEDTRA 10061.

Each time a rate training manual is revised, it is brought into conformance with the official publications and directives on which it is based; but during the life of any edition, discrepancies between the manual and the official sources are almost certain to arise because of changes to the latter which are issued in the interim. In the performance of your duties, you should always refer to the official publication or directive.

Rate training manuals help you meet the occupational standards required by the Navy. The following suggestions may help you to make the best use of the RTM and other Navy training publications:

1. Study the naval standards and the occupational standards before you study the training manuals, and refer to them frequently as you study. Ask your educational services officer for an Occupational Standards and Bibliography Sheet or NAVPERS 18068. Remember, you are studying the manual to aid you in performing your job. The minimum requirements for the job are listed in NAVPERS 18068.

2. Set up a regular study plan. It will probably be easier for you to stick to a schedule if you can plan to study at the same time each day. If possible, schedule your studying for a time of day when you will not have too many interruptions or distractions.

3. Before you begin to study any part of the manual intensively, become familiar with the entire book. Read the preface and the table of contents. Check through the index. Look at the appendices. Thumb through the book without any particular plan, looking at the illustrations and reading bits here and there as you see things that interest you.

4. Look at the training manual in more detail, to see how it is organized. Look at the table of contents again. Then, chapter by chapter, read the introduction, the headings, and the subheadings. This will give you a pretty clear picture of the scope and content of the book. As you look through the book in this way, ask yourself some questions:

What do I need to learn about this?
What do I already know about this?
How is this information related to information given in other chapters?
How is this information related to the occupational standards?

5. When you have a general idea of what is in the training manual and how it is organized, fill in the details by intensive study. In each study period, try to cover a complete unit—it may be a chapter, a section of a chapter, or a subsection. The amount of material that you can cover at one time will vary. If you know the subject well or if the material is easy, you can cover quite a lot at one time. Difficult or unfamiliar material will require more study time.

6. In studying any one unit—chapter, section, or subsection—write down the questions that occur to you. Many people find it helpful to make a written outline of the unit as they study, or at least to write down the most important ideas.

7. As you study, relate the information in the training manual to the knowledge you already have. When you read about a process, a skill, or a situation, try to see how this information ties in with your own past experience.

8. When you have finished studying a unit, take time out to see what you have learned. Look back over your notes and questions. Maybe some of your questions have been answered, but perhaps you still have some that are not answered. Without looking at the training manual, write down the main ideas that you have gotten from studying this unit. Don't just quote the book. If you can't give these ideas in your own words, the chances are that you have not really mastered the information.

9. Use nonresident career courses whenever you can. The nonresident career courses are based primarily on rate training manuals and basic manuals. As mentioned before, completion of a mandatory rate training manual can be accomplished by passing a nonresident career course based on the rate training manual or by a locally prepared test on the manual. You will probably find it helpful to take other nonresident career courses, as well as those based on mandatory manuals. Taking a nonresident career course helps you to master the information given in the training manual and also helps you see how much you have learned.

10. Think of your future as you study rate training manuals. Anything you learn now will help you to advance both now and later.

NONRESIDENT CAREER COURSES

As previously mentioned, a nonresident career course (NRCC) is based on a rate training manual or a basic manual. Its purpose is to provide you with a self-study training course for accomplishment at your local command.

The NRCC contains a set of assignments and self-scoring answer sheets (SSASs). The SSASs are packaged separately and are usually ordered from Publications and Forms Center, Philadelphia. See your educational services officer for assistance in ordering the appropriate SSASs.

NRCCs that are associated with or contain information pertaining to your rate are recommended for completion. This information is also contained in the Bibliography for Advancement Study, NAVEDTRA 10052, which also lists those courses that are recommended for completion.

EXAMINATION PROCEDURES

The Navywide examinations for advancement are written at the Naval Education and Training Program Development Center, Pensacola, Florida. The exam writers are senior enlisted personnel who are experts in the rating for which the exam is written (e.g., the RM3 exam is written by a senior Radioman).

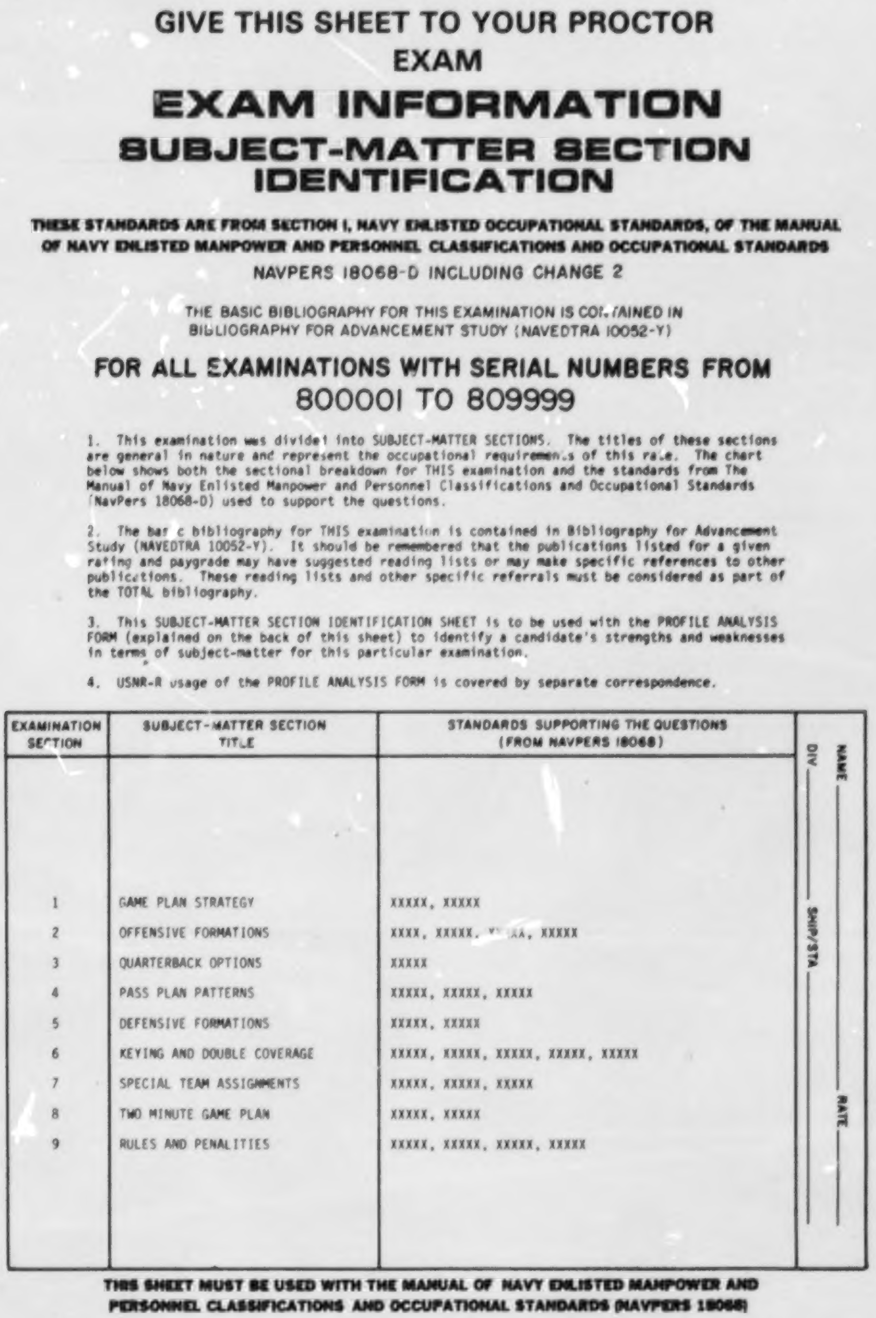
The exams are normally administered by the commands to which the examinees are attached. In the case of smaller commands with only a few examinees attached, the exam may be administered by a larger command. For example, a naval legal services office may have only one or two people taking the exam. Therefore, the exam may be administered by the naval station of which the naval legal services office is a tenant command.

TAKING THE EXAM

Several days prior to the exam date, the educational services officer will ask you to verify the Recommendation Worksheet, NAVEDTRA 1430/2, which has been prepared for you. You should check the worksheet very carefully since this information will be used in computing your "beginning multiple." If any of the information shown on your worksheet is incorrect, bring it to the attention of the educational services officer so that it may be corrected.

The commanding officer of the command administering the exam will schedule a place for the exam to be given and will notify the examinees as to where and when to meet. This is usually done through a notice in the Plan of the Day. Several proctors (officers and/or senior enlisted personnel) will be present during the testing period. These people are there to assist you in assuring that your answer sheet is properly prepared.

When you sit down to take the test, the proctor will advise you on how to fill out the answer sheet. These answer sheets are scored by an optical scanner and must be completed very carefully. Listen closely to what the proctor



GIVE THIS SHEET TO YOUR PROCTOR

EXAM

EXAM INFORMATION

SUBJECT-MATTER SECTION IDENTIFICATION

THESE STANDARDS ARE FROM SECTION I, NAVY ENLISTED OCCUPATIONAL STANDARDS, OF THE MANUAL OF NAVY ENLISTED MANPOWER AND PERSONNEL CLASSIFICATIONS AND OCCUPATIONAL STANDARDS

NAVPERS 18068-D INCLUDING CHANGE 2

THE BASIC BIBLIOGRAPHY FOR THIS EXAMINATION IS CONTAINED IN BIBLIOGRAPHY FOR ADVANCEMENT STUDY (NAVEDTRA 10052-Y)

FOR ALL EXAMINATIONS WITH SERIAL NUMBERS FROM 800001 TO 809999

1. This examination was divided into SUBJECT-MATTER SECTIONS. The titles of these sections are general in nature and represent the occupational requirements of this rate. The chart below shows both the sectional breakdown for THIS examination and the standards from The Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards (NavPers 18068-D) used to support the questions.

2. The basic bibliography for THIS examination is contained in Bibliography for Advancement Study (NAVEDTRA 10052-Y). It should be remembered that the publications listed for a given rating and paygrade may have suggested reading lists or may make specific references to other publications. These reading lists and other specific referrals must be considered as part of the TOTAL bibliography.

3. This SUBJECT-MATTER SECTION IDENTIFICATION SHEET is to be used with the PROFILE ANALYSIS FORM (explained on the back of this sheet) to identify a candidate's strengths and weaknesses in terms of subject-matter for this particular examination.

4. USNR-R usage of the PROFILE ANALYSIS FORM is covered by separate correspondence.

EXAMINATION SECTION	SUBJECT-MATTER SECTION TITLE	STANDARDS SUPPORTING THE QUESTIONS (FROM NAVPERS 18068)
1	GAME PLAN STRATEGY	XXXXX, XXXXX
2	OFFENSIVE FORMATIONS	XXXX, XXXXX, XXXXX, XXXXX
3	QUARTERBACK OPTIONS	XXXXX
4	PASS PLAN PATTERNS	XXXXX, XXXXX, XXXXX
5	DEFENSIVE FORMATIONS	XXXXX, XXXXX
6	KEYING AND DOUBLE COVERAGE	XXXXX, XXXXX, XXXXX, XXXXX, XXXXX
7	SPECIAL TEAM ASSIGNMENTS	XXXXX, XXXXX, XXXXX
8	TWO MINUTE GAME PLAN	XXXXX, XXXXX
9	RULES AND PENALITIES	XXXXX, XXXXX, XXXXX, XXXXX

NAME ________ RATE ________

DIV ________ SHIP/STA ________

THIS SHEET MUST BE USED WITH THE MANUAL OF NAVY ENLISTED MANPOWER AND PERSONNEL CLASSIFICATIONS AND OCCUPATIONAL STANDARDS (NAVPERS 18068)

6.152

Figure 1-4.—Subject-Matter Section Identification Sheet.

tells you, and double check the information on your answer sheet. An error on this part of the answer sheet can often mean a delay in finding out how well you did on the exam.

Subject-Matter Section Identification Sheet

When you complete the exam, you will be told to give the Subject-Matter Section Identification Sheet to your proctor. This sheet is the back cover of the exam booklet. (See figure 1-4.) This tear-off sheet lists the general subject matter areas and occupational standards which were covered on the exam. The tear-off sheet will prove useful to you in analyzing your exam results when you compare it to the profile analysis form which you will receive after the exam has been graded.

Profile Analysis Form

When the exam results are returned to your command, you will be given a profile analysis form showing your individual results. (See figure 1-5.)

Space 1, Examination Status, shows whether you passed or failed, and your exam score (e.g., FAIL/42 means you failed the exam, and your exam standard score was 42).

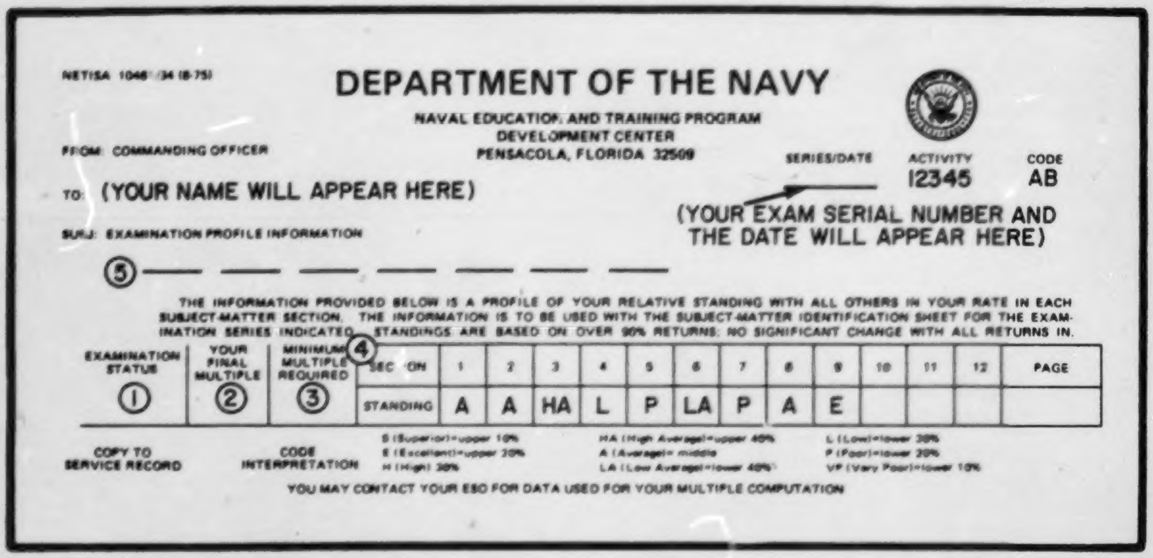
Space 2, Your Final Multiple, shows your final multiple, the computation of which was previously discussed.

Space 3, Minimum Multiple Required, shows the minimum final multiple required for advancement within your rating. Those individuals whose final multiples were the same, or higher, as that shown in this space were advanced.

Space 4, (Sections 1-12), consists of Section and Standing. The section number corresponds to the section number shown on the Subject-Matter Section Identification Sheet (fig. 1-4), and the standing reflects how well you did in relation to all others taking the same test. By comparing figures 1-4 and 1-5, you see that, in relation to everyone else taking this particular test, this person did poorly in the area of section 7, but did excellently in the area of section 9.

Space 5 will show the Passed Not Advanced points assigned to those who passed the exam but were not advanced. As mentioned earlier, these points will become a part of the beginning multiple for the next exam. Ask your educational services officer for more information about this.

In summary, the occupational standards manual, NAVPERS 18068 (series), provides a list of the basic occupational skills for your rating and paygrade; Personnel Qualification Standards (PQS) assist you in developing these skills; rate training manuals and nonresident career courses provide a method for acquiring the knowledge associated with these skills. The


NETISA 1046/34 (8-75)

DEPARTMENT OF THE NAVY
NAVAL EDUCATION AND TRAINING PROGRAM
DEVELOPMENT CENTER
PENSACOLA, FLORIDA 32509

FROM: COMMANDING OFFICER

TO: (YOUR NAME WILL APPEAR HERE)

SERIES/DATE ________

ACTIVITY 12345

CODE AB

(YOUR EXAM SERIAL NUMBER AND THE DATE WILL APPEAR HERE)

SUBJ: EXAMINATION PROFILE INFORMATION

⑤ ___ ___ ___ ___ ___ ___ ___

THE INFORMATION PROVIDED BELOW IS A PROFILE OF YOUR RELATIVE STANDING WITH ALL OTHERS IN YOUR RATE IN EACH SUBJECT-MATTER SECTION. THE INFORMATION IS TO BE USED WITH THE SUBJECT-MATTER IDENTIFICATION SHEET FOR THE EXAMINATION SERIES INDICATED. STANDINGS ARE BASED ON OVER 90% RETURNS; NO SIGNIFICANT CHANGE WITH ALL RETURNS IN.

EXAMINATION STATUS	YOUR FINAL MULTIPLE	MINIMUM MULTIPLE REQUIRED	④ SECTION	1	2	3	4	5	6	7	8	9	10	11	12	PAGE
①	②	③	STANDING	A	A	HA	L	P	LA	P	A	E				

COPY TO SERVICE RECORD

CODE INTERPRETATION

S (Superior)=upper 10%
E (Excellent)=upper 30%
H (High) 30%
HA (High Average)=upper 40%
A (Average)= middle
LA (Low Average)=lower 40%
L (Low)=lower 30%
P (Poor)=lower 20%
VP (Very Poor)=lower 10%

YOU MAY CONTACT YOUR ESO FOR DATA USED FOR YOUR MULTIPLE COMPUTATION

76.153

Figure 1-5.—Profile Analysis Form.

Navy advancement system is based on a competitive Navywide exam and your demonstrated skills documented by the Personnel Advancement Requirements (PAR) program.

Your educational services officer can provide more detailed explanations of the Navy's training programs, assist you in establishing your own study program, and provide both information and materials for your advancement study. He can provide information on college programs, high school equivalency exams, Navy schools, local training courses, etc. He also has available to him a list of the latest Navy Training Films and the Navy publications you will require.

No single publication can give you all the information you need to perform the duties of your rating. You should learn where to look for accurate, authoritative, up-to-date information on all subjects related to the naval requirements and the occupational standards of your rating.

CHAPTER 2

BASIC ELECTRICITY

At this point in your naval career, you could probably describe yourself in one of the following ways: (1) You are a Seaman or Third-Class just graduated from Radioman "A" school, (2) you are a Seaman or Third-Class, a graduate of Radioman "A" school, and currently serving somewhere in the fleet or ashore, or (3) you are a Seaman or a Third-Class who has decided to strike for the Radioman rating without the benefit of Radioman "A" school. While attending Radioman "A" school, you found much of your training to be "clerically" or "operationally" oriented. Hence, it is quite natural to ask yourself the question: "Why do I have to know anything about electricity or electronics?"

It is important to realize that, as you advance in the Radioman rating, more will be expected of you. Not only will your responsibilities in the area of leadership increase, but also more will be expected from you in the area of professional knowledge and skill. In other words, your "store-of-knowledge" must be greater. Add to that the fact that the Radioman rating is probably broader and encompasses more areas than any other single rate in the Navy today, and you have two very important reasons for being as versatile as you can possibly be.

There are a variety of types of ships in the Navy today. Each type or class of ship has a basic mission which depends upon its capabilities. Each communication center on each ship is in some way different. Therefore, your job as a Radioman can conceivably encompass everything from equipment set-up, antenna tuning, basic trouble-checks, and minor preventive and corrective equipment maintenance, to message preparation, routing, and filing. There is an old communications axiom that "knob-twisters are not only a dime-a-dozen, but they are also dangerous." In other words, not knowing the "why" of things may obscure the possible dangers involved in the performance of any job.

This chapter not only serves as an introduction to basic electrical terminology and definition, but it is also intended to aid you in your understanding of the material contained in succeeding chapters on Basic Transmitter and Receiver Theory, Test Equipment and Quality Assurance, and Antennas and Radio Wave Propagation. It is the objective of Chapters 2 through 8 of this Rate Training Manual to introduce you to the basics involved in those areas of the Radioman rating and to prepare you for the complexities involved as you advance in rate.

WHAT IS ELECTRICITY?

The question, "What is electricity?", has been asked countless times in the past. A good description of electricity would be the movement of free electrons. The effects of electricity and electronics are explained according to the ELECTRON THEORY. Through the use of the electron theory, we have found that electricity has a predictable nature and may be controlled. At this point, depending upon your electronics background, you may or may not be asking, "What is an electron?"

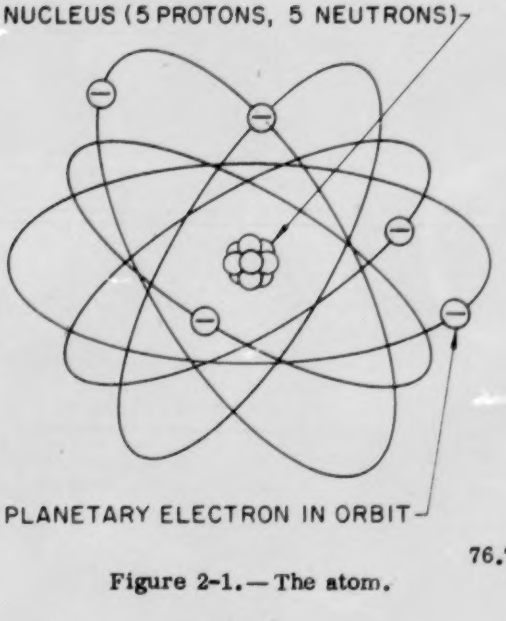
Many people have allowed themselves to become confused in discussions of matter or energy as related to the electron theory. So for purposes of this discussion, we will detail only those terms and definitions concerned with the essentials of the electron theory.

BASIC PARTICLES OF MATTER

To understand the electron, we must first understand the basic structure of matter. MATTER can be defined as anything having mass and inertia and occupying any amount of space. An example of matter is iron, which is solid matter. An example of liquid matter is water, and an example of gaseous matter is water vapor. So now we know that matter may exist in solid, liquid, or gaseous form.

The Atom

An ATOM is defined as the smallest particle of any element. This stands to reason because the theory of the atom is the basis for all life and matter. Let's take a look at an atom and understand the different parts of it. (Refer to figure 2-1.) In the center or "core" of the atom, we see the NUCLEUS. Most of the mass of the atom is contained in the nucleus. The nucleus may be equated to the sun around which all of the planets revolve. The nucleus contains PROTONS (positively charged particles) and NEUTRONS (electrically neutral particles). Whirling around the nucleus, much as the planets whirl around the sun, are ELECTRONS (negatively charged particles). Normally, there is one proton for each electron so that the net positive charge of the nucleus is balanced by the net negative charge of the electrons. Thus the atom is ELECTRICALLY NEUTRAL. Normally, unlike charges will attract each other; however, the centrifugal force of the revolution of the electron in its orbit prevents the electron from being drawn into the nucleus. It should be understood that not all atoms have the same number of electrons. For example, hydrogen has only one electron, whereas curium has 96 electrons in each atom.



76.79

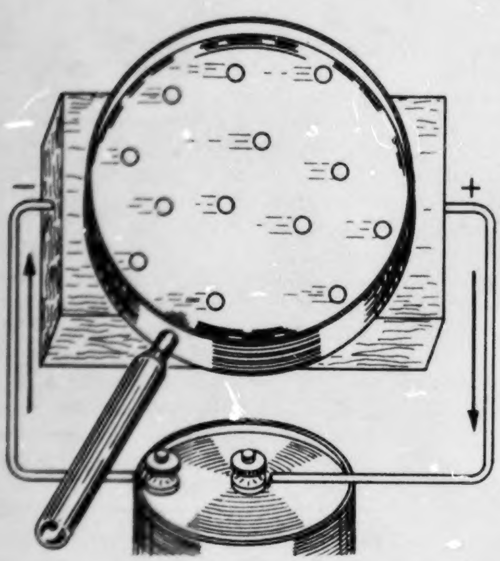
Figure 2-1.—The atom.

The Molecule

A MOLECULE is defined as the combination of two or more atoms to form the smallest part of a compound. For example, when the compound water is formed, two atoms of hydrogen and one atom of oxygen combine to form a molecule of water. A single molecule is very small and is not visible to the eye. Therefore, a few drops of water may contain as many as a million molecules. A single molecule is the smallest particle into which the compound may be broken down and still be the same substance. Once the last molecule of a compound is divided into atoms, the substance no longer exists.

Now let's relate these several definitions to the original question, "What is electricity?" We know that it is the movement of free electrons, and we also know that an atom is electrically neutral. A whole molecule or a whole atom may be electrically neutral, but the electrons and protons within the atom are not. Electrons and protons are referred to as SUBATOMIC PARTICLES, and they are electric in nature. That is to say, they are the particles of matter most affected by an electric force. Protons are inherently positive and electrons are inherently negative. It is this inherent characteristic of each which makes them sensitive to an electric force.

To simplify the electron theory, figure 2-2, we have expanded a piece of copper wire (considered to be a good conductor) and shown the action of individual atoms within the copper. We have also applied an "electric force" mentioned above in the form of a simple battery. When we connect both ends of the copper wire to the terminals of the battery, the electrical difference between the negative and positive terminals causes the orbiting electrons to be randomly "pulled" out of their respective orbits toward the positive terminal. Those electrons pulled out of orbit are referred to as FREE ELECTRONS. These free electrons then collide with oribiting electrons of neighboring atoms, knocking them out of orbit, thus making them free electrons as well. These free electrons are all moving toward the positive terminal, and this process is happening simultaneously in millions of atoms within the copper conductor. This process will continue until there is no longer an electric force applied or until there is no longer an electrical "difference" between the two ends of the copper conductor. This "difference" will be discussed later in the chapter. The movement of these free electrons is representative of the electron theory. Probably, not one of the



76.80

Figure 2-2.—Free electrons.

electrons flows around the entirety of the electric circuit represented in figure 2-2; rather, it is the chain reaction of electrons being displaced simultaneously by the millions that constitute electron flow, or current flow. Current will also be discussed later in the chapter. Now you know the "electron theory", and as you can see, it's very simple.

There is one point remaining to be covered before you can fully understand the WHY of electron flow. The question has been asked, "Why does the electron move and not the proton?" The answer to that question may be answered in one word: WEIGHT. The protons in atoms are tremendously heavy. Even in the element of hydrogen, which has the lightest proton weight of all the elements, the proton is approximately 1,850 times heavier than its electron. Therefore, it is the lighter electron which is most affected by electrical force, which brings us to our next term, IONIZATION.

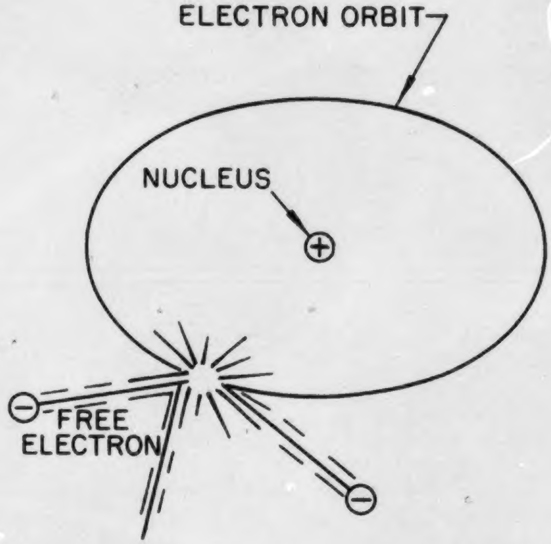
Ionization

As we know, it is possible to drive one or more electrons out of their respective orbits. It is also possible to cause one or more electrons to be attached to an atom, giving that atom an over-abundance of electrons. In either case, whether the atom gains or loses electrons, it is said to be IONIZED. An atom having more than its normal amount of electrons acquires a negative charge, since electrons are electrically negative and is called a NEGATIVE ION. An atom that loses some of its electrons is left with more protons than electrons, and since protons are electrically positive, the atom is called a POSITIVE ION. Thus, IONIZATION is the process by which an atom loses or gains electrons. (See figure 2-3.)

Some materials are easier to ionize than others. By that we mean that some of the atoms of certain metallic atoms are so loosely bound to their nuclei that they are comparatively free to move from atom to atom. Thus, only a very small amount of energy or force is needed to cause such electrons to become free electrons. This energy, or force, or "electrical force" as we have referred to it, is said to be the source of excitation, or the atom is said to be EXCITED.

CONDUCTORS AND INSULATORS

Substances that permit the free motion of large numbers of electrons are called CONDUCTORS. Copper wire is considered a good



76.81

Figure 2-3.—Free electron colliding with orbiting electron causing ionization.

conductor because it has many free electrons. Electrical energy is transferred through the conductor by means of the movement of free electrons that migrate from atom to atom inside the conductor. Refer back to figure 2-2. Each electron moves a very short distance to the neighboring atom where it replaces one or more electrons by forcing them out of their orbits. The replaced electrons repeat the process in other nearby atoms until the movement is transmitted throughout the entire length of the conductor. The greater the number of electrons that can be made to move in a material under the application of a given force, the better are the conductive qualities of that material. A good conductor is said to have a low opposition or low resistance to current (electron) flow.

Some of the more commonly used metal conductors are silver, copper and aluminum. Of these three, the best conductor is silver. However, copper is more commonly used because it is less expensive than silver. The ability of a material to conduct electricity is also dependent upon its dimensions. By this we mean its length, width, cross-sectional area, etc. Temperature is another important factor that determines the ability of a material to conduct electricity.

Some materials give up very few free electrons and very large amounts of energy or force must be used to break the electrons loose within the material. These materials are called INSULATORS. Actually, electron motion is known to exist to some extent in all materials. The more conductive materials are used as conductors and the less conductive ones as insulators. Listed below are some of the best conductors and insulators, shown in accordance with their respective abilities to conduct or resist the flow of electrons.

Conductors	Insulators
Silver	Dry Air
Copper	Glass
Aluminum	Mica
Zinc	Rubber
Brass	Asbestos
Iron	Bakelite

There is a "gray" area existing between conductors and insulators. That is to say that there are some materials that are neither good conductors nor good insulators. Depending upon the circumstances, some material may act either as a conductor or an insulator. These materials are called SEMICONDUCTORS. Germanium and Silicon are examples of materials in this category. It should be mentioned that there are many things affecting the ability of a material to either conduct or resist the conduction of electricity (electrons).

Factors Affecting Electron Conduction

The science of determining the proper type of material to be used in electronic circuits or in the wiring of these circuits is a very complex one. The purpose of this discussion is to acquaint you with some of the terms that you may come into contact with as well as their meanings. As was mentioned, many things affect the ability of a material to conduct. The resistance offered by a conductor to the flow of electrons is referred to as the RESISTIVITY or SPECIFIC RESISTANCE of that conductor. The resistivity or specific resistance of a material is proportional to that conductor's length and cross-sectional area. The longer the conductor, the more resistance it will offer to electron flow. The wider the conductor, the less resistance it will offer to electron flow. Therefore, we can say that the resistance of a conductor varies directly with its length and inversely with its width or cross-sectional area.

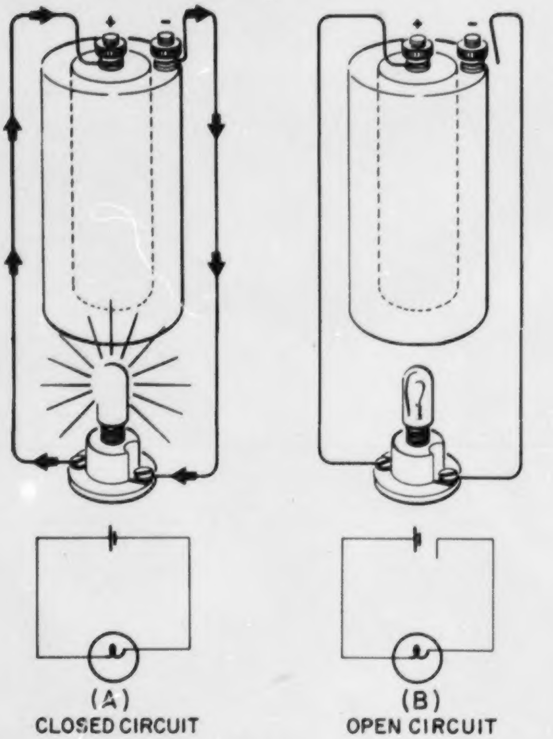
TEMPERATURE affects different materials in different ways. For example, the resistance of pure metals—such as silver, copper and aluminum—increases as the temperature increases. However, some materials such as constantan and manganin, change very little as the temperature changes. The amount of increase in the resistivity of a conductor in reference to a set per-degree rise in temperature is called the temperature coefficient of resistance. Although the term itself is quite long, the meaning of it is simple. Remember, the ability of a conductor to conduct electrons is called its CONDUCTIVITY; whereas, the ability of a conductor to resist the flow of electrons through it is called its RESISTIVITY or SPECIFIC RESISTANCE.

Another important factor affecting conducting materials is the so-called BREAKDOWN POTENTIAL of that material. The term itself simply means the amount of current or power that the conducting material is capable of handling before it "breaks down" or is destroyed. We haven't discussed power yet. That is covered later in this chapter along with its relationship to current.

THE SIMPLE ELECTRIC CIRCUIT

Thus far, we have defined electricity and gained a little insight as to the why of electron flow. The next step is to take a simple electric circuit and discuss the components comprising it. We will also define and discuss the electrical values associated with any electrical circuit.

In figure 2-4 we have shown the most simple circuit. The battery is the source of electrical energy. The two wires connected to the negative (-) and positive (+) terminals of the battery and to the light represent the conductors of electricity. The light represents the LOAD, or the receiver of electrical energy. On the left (figure 2-4(A)), we have shown a CLOSED CIRCUIT. This simply means that there is a complete pathway for current to flow. When this happens, the light will be lit by the electrical energy received from the battery. On the right (figure 2-4(B)), we have shown an OPEN CIRCUIT. This means that there is no longer a complete pathway for current to flow. We may "open" the circuit by simply removing the conductor from either terminal of the battery, or we could have accomplished the same thing by removing the conductor from either terminal of the light. In either case, electrons would not flow through the light and the light would not be lit. Remember, current will flow only in a closed or complete circuit.



(A)
CLOSED CIRCUIT

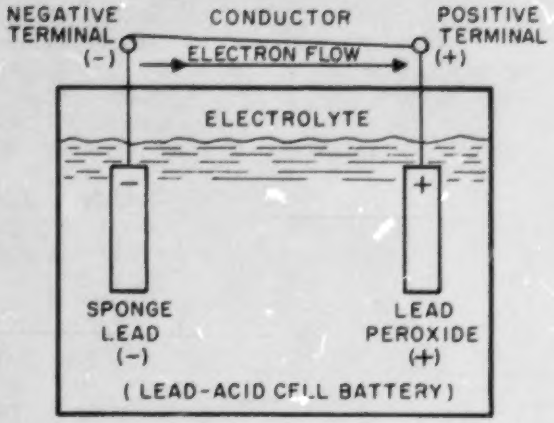
(B)
OPEN CIRCUIT

236.41

Figure 2-4.—(A) Simple electric circuit (closed). (B) Simple electric circuit (open).

Before we may proceed further with our analysis of a simple electric circuit, one fact must be understood. In all cases and under all circumstances, electron flow (or current flow) is always from NEGATIVE to POSITIVE. Referring back to figure 2-4, we notice that the arrows indicating current flow show that the electrons move from the negative (-) terminal, through the light, and back to the positive (+) terminal of the battery. This happens because the negative terminal is attached to material that is more negatively charged than the positive terminal. This means that the negative material has a greater abundance of electrons than does the positive material. A material that has such an abundance of electrons is said to be more NEGATIVELY CHARGED in relation to the positive material. If we were to take two conducting materials, one more negatively charged than the other and place them side-by-side, nothing would happen. However, if we were to attach these materials with a conductor as shown in figure 2-5, then we would have current flow from the negatively charged material to the positively charged material. This happens because electrons, like water, seek an equal level. The different charges existing on the materials in figure 2-5 tend to equalize or "balance out"; therefore, the excess of electrons in the negative material will flow toward the positive material until there is an equal charge existing on both materials. When equal charges exist, current ceases to flow and the circuit is then in what is referred to as a "static" state due to the balance of the two materials.

Whenever two sources of electrical energy such as those depicted in figure 2-5 have different electrical levels, they are said to have a DIFFERENCE IN POTENTIAL. It is this difference in potential that causes current to flow in an electrical circuit. Without a difference in electrical potential, there could be no current



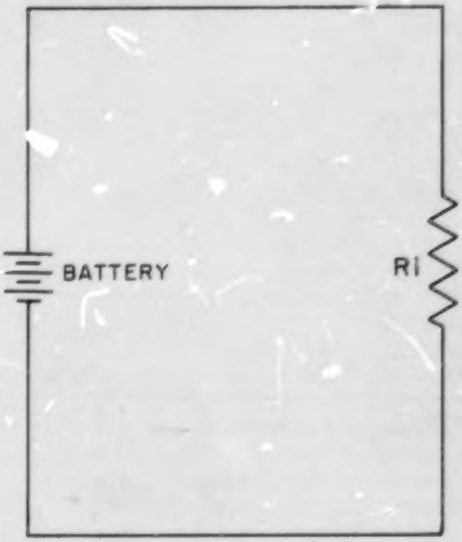
76.82
Figure 2-5.--Electron flow from negatively charged material (-) to positively charged material (+).

flow. Therefore, it is very important that we understand potential difference, what it means, and how it is used.

Schematic Representation

Before we may proceed with the discussion of electrical circuits and their associated values, a schematic should be defined and explained. First of all, what is a schematic? A SCHEMATIC is a diagram in which symbols are used for the various components contained in electrical circuits. These symbols make diagrams of electrical circuits easy to draw and easier to understand. In addition to that, they save space. In figure 2-4 we showed a battery connected to a light bulb via two conducting wires. Below each battery in figure 2-4 we have shown the schematic equivalent of both the closed and open circuit. In figure 2-6 we have shown another schematic equivalent of a basic circuit. The only difference between the two figures is that we have included a resistor designated as R1, instead of a light bulb in figure 2-6. We have not discussed resistors yet. This will be discussed later in this chapter.

This concludes our discussion of basic matter and answers our question: What is electricity? We are now ready to go into the various values that may be derived and computed from electrical circuits, such as voltage, current, resistance and power.

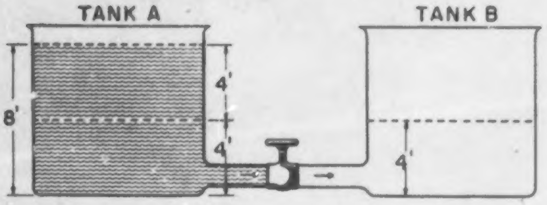


236.42
Figure 2-6.—Schematic diagram of a basic circuit.

VOLTAGE

Voltage may be defined as "the force which causes free electrons to move in a conductor as an electric current." Whenever two unequally charged bodies are connected by a conductor, electrons will flow along the conductor. This flow is from the negatively charged body to the positively charged body until the two charges are equalized. This occurs because of the DIFFERENCE IN POTENTIAL that exists between these two charged bodies. Let's take a look at figure 2-7 and see a simple demonstration of this process.

What we have shown in figure 2-7 are two water tanks connected by a pipe with a stop-valve attached to it. In tank A, the water level is near the top; whereas in tank B, there is no water. Think of tank A as a very negatively charged body with the water representing an over-abundance of electrons. Think of tank B as a very postively charged body representing fewer electrons with its emptiness. Lastly, think of the pipe as a conductor. When we attach the



236.20
Figure 2-7.—Water/tank representation of "difference-in-potential".

conductor, represented by the pipe, to the two charged bodies (tanks A and B), water will flow from tank A to tank B until an equal level is reached in each. We simulate this action by opening the valve, which would be the same thing as connecting the conductor. When the water level is equal, no more water will flow from tank to tank. The flow of electrons is very similar in action in that when the charges are equal, electron flow will cease due to the lack of "difference in potential."

As we will learn later in this chapter, voltage can be measured when we know the values of current and resistance. The term for measured voltage is the VOLT. It is a term you will become familiar with as you continue in your study of electricity. Circuit voltage values are represented by the letter "E" followed by the numerical value, e.g. E = 100 volts.

There is one other term associated with voltage and "difference in potential." It is called ELECTROMOTIVE FORCE (emf). These three terms—voltage, difference-in-potential, and electromotive force (emf)—are all one and the same; so don't be confused by them.

There are six different methods of producing a voltage. Some of these methods are more widely used than others. The following is a list of the six methods of producing a voltage:

1. FRICTION — Voltage produced by rubbing two materials together.

2. PRESSURE — (Piezoelectricity) — Voltage produced by squeezing crystals of certain substances.

3. HEAT—(Thermoelectricity) — Voltage produced by heating the junction where two unlike metals are joined.

4. LIGHT — (Photoelectricity) — Voltage produced by light striking photosensitive (light sensitive) substances.

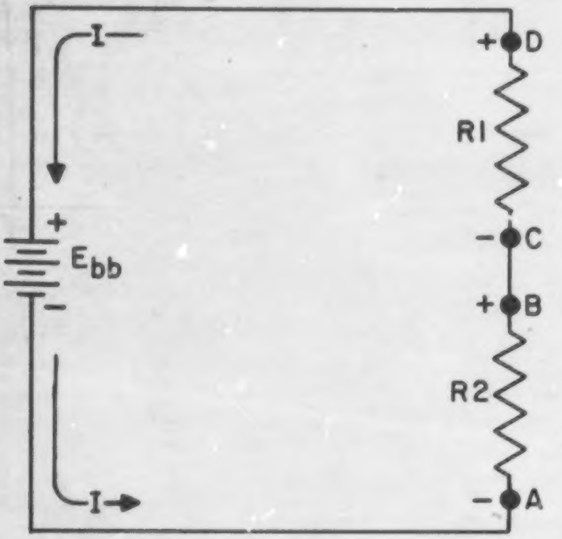
5. CHEMICAL ACTION — Voltage produced by chemical reaction in a battery.

6. MAGNETISM — Voltage produced when a conductor moves through a magnetic field or a magnetic field moves through a conductor.

Now you know what voltage is, how it is measured (in volts and abbreviated "V"), the three most common names for it, and the six ways of producing it. We will learn to compute voltage later in this chapter. For the moment, however, you need only be familiar with the term and what it means. Detailed descriptions of the methods of producing voltage are contained in BASIC ELECTRICITY, NAVEDTRA 10086 series. As was mentioned earlier, in order to compute voltage, you must have other values available to you, such as current and resistance. The next topic will be a discussion of current.

CURRENT

Electric CURRENT is no more than the drift or flow of electrons through a conductor. The direction of this drift or flow of electrons is from a negative potential towards a less-negative potential or a positive potential. This direction is determined by the polarity of the voltage source. There is a word we haven't discussed yet: POLARITY. To better understand this word, take a look at figure 2-8. Here we have shown a battery source voltage and two resistors (represented by R1 and R2). We show electron flow coming from the negative terminal of the battery, through R2, then R1, and returning to the positive terminal of the battery. We have also shown that because the electron flow is a negative value, the point at which the current enters the two resistors is more negative than the point at which the current leaves. Therefore, we can indicate the positive and negative points with the markings of (+) for positive and (-) for negative. That is all that polarity is, simply the different electrical charges existing at different points in a circuit. This term will be used time and again throughout our study of electricity and circuit solving. The easiest way to understand the word "polarity" is to think of the terminals of a battery. The negative terminal is more negatively charged than the positive terminal. Therefore, its POLARITY MARKING is (-), whereas the polarity marking of the positive terminal is (+). They exist at two different electrical potentials.



236.67
Figure 2-8.—Polarity markings.

There are two classifications of current movement: RANDOM DRIFT and DIRECTED FLOW. First, let's understand what "random-drift" is and what causes it. We mentioned earlier that when an atom gains or loses an electron, it is said to be ionized. In some materials, ionization occurs quite easily. For example, some conductors are made up of atoms that contain very loosely bound electrons. These loosely-bound electrons may break away from their respective orbits at room temperature. These free electrons, also called "mobile" electrons, take a path that is not predictable and drift around within the material in a haphazard manner. Such a movement is called random drift.

DIRECTED FLOW has already been discussed to some degree. You already know that whenever a conducting material is connected to the negative and positive terminals of a battery, the "difference in potential" between the two terminals will immediately cause the electron chain-reaction discussed earlier. These free electrons will flow towards the more positive point. This is called directed flow.

In electronic circuits and schematics, we symbolize current with the letter designation "I". Just as voltage is measured in volts, we must have a term that determines the amount, or number, of electrons flowing in a given conductor. The term AMPERE is the unit of measurement that defines the RATE at which current flows. We measure current in amperes and this is usually abbreviated amp. One ampere, or amp, may be defined as the flow of 6.28×10^{18} electrons per second past a fixed point in a conductor.

Another term that needs to be understood in relation to current is COULOMB. The coulomb is a unit quantity of electricity much as a gallon is a unit quantity of liquid. A coulomb is a measure of electric charge equal to that carried by 6.28×10^{18} electrons. Get it straight. The ampere is the RATE at which current flows; the coulomb is the QUANTITY of electrons. They are inter-related through the common factor of TIME (t). Therefore, the quantity of electrons in coulombs (symbolized "Q") that is moved through a circuit is equal to the product of the current in amperes, I, and the duration of flow in seconds, t. Expressed as an equation, $Q = It$.

For example, if a current of 2 amps flows through a circuit for 10 seconds, the quantity of electricity moved through the circuit is 2 x 10 or 20 coulombs. Conversely, current flow may be expressed in terms of coulombs and time. If 20 coulombs are moved through a circuit in 10 seconds, the average current flow is $\frac{20}{10}$, or 2 amperes. Thus, a current flow of 2 amps is equal to 2 coulombs per second. Remember, one is rate; one is quantity.

The ampere is normally much too large a unit to work with in electronic equipments. Usually, current only flows at very low rates, such as MILLIAMPERES (ma) which is one-thousandth $(\frac{1}{1000})$ of an ampere, or MICROAMPERES (ua) which is one-millionth $(\frac{1}{1,000,000})$ of an ampere. As you can see, many things in electricity are associated in some manner with time. This is something that you will see often in your study of electricity. Time is in some way related to all electricity. If it is not normally part of an equation, it is used to derive one of the values used in the equation. Later in this manual, when we learn to calculate electrical values and enter into a.c. theory, you will further appreciate the element of time in basic electricity.

RESISTANCE

The term RESISTANCE may be defined as "the opposition to current flow in an electric circuit." It should be pointed out that every material or part of a circuit has some resistance that it offers to current flow. As you already know, even the conducting wire itself offers some resistance due to its length and cross-sectional area. Naturally, we use the size and type of materials that offer minimum resistance to electron flow in circuits.

Resistance in a circuit may either be a natural resistance or a man-made one, designed for a specific purpose. For example, in figure 2-4, the natural resistance of the circuit is that resistance contained within the battery, the conducting wires, and the light-bulb. However, in some circuits we will insert deliberate resistance into a circuit to accomplish an end. If you refer to Appendix II at the end of this manual, "Mechanical and Electrical Symbols", you will see the electrical symbol for a RESISTOR. Many resistors are made today in many sizes and fixed values specifically for electronic circuits. This is because all circuits have a purpose, and there is something in particular that we want that circuit to accomplish for us. It takes a fixed combination of components and potentials to achieve this end many times. Therefore, we manufacture deliberate resistances for circuits. The symbol for a resistor may indicate the natural resistance of a circuit or a man-made, fixed resistance. In either case, we are able to determine the value of resistance in circuits and, by doing so, can aid in finding other values in a circuit, such as voltage and current.

Resistance in a circuit is measured in OHMS and is symbolized by the letter "Omega" (indicated also in Mechanical and Electrical Symbols). One "ohm" of resistance is considered to exist whenever a circuit element permits 1 ampere of current (1 coulomb per second) to flow when an emf (voltage) of 1 volt is applied. The formula is expressed, R (resistance) = $\frac{E \text{ (voltage)}}{I \text{ (current)}}$. In fact, we may now derive an electrical formula to cover the topics of voltage, current, and resistance. The formula is $E = I \times R$. This means that we can multiply current (I) times resistance (R) to find voltage (E). To find any value of the three, all you have to do is transpose the formula accordingly. For example, if we want to find resistance, we simply divide voltage by current: $\frac{E}{I}$. To find current, we simply divide voltage by resistance: $\frac{E}{R}$. We will be using this formula in our circuit calculations later in this chapter.

CONDUCTANCE

Quite often in electricity you will find that we use opposites to determine different values in a circuit. An example of this is the term CONDUCTANCE. The term may sound complex, but it merely means the opposite of resistance. For example, we say that the ability of a component to oppose current flow is "resistance." The ability of a component or material to pass electrons is known as its conductance.

Conductance is the opposite of resistance, or to be more precise, its RECIPROCAL. A reciprocal of a number is obtained by dividing the number into one. In other words, if the resistance of a particular component or material is 6 ohms, we would divide that figure into 1 to find the conductance of that component or material. This could be expressed as $\frac{1}{6}$, and the answer would be: .166. This answer would be expressed in the term MHOS. We use mhos because mho is the word "ohm" spelled backward. Conductance is the exact opposite of resistance, and it is indicated by the designation "G". We may now derive a formula that is constant in terms of conductance and resistance:

$$G = \frac{1}{R}$$

or

$$R = \frac{1}{G}$$

POWER

POWER may be defined as the RATE at which work is done. Whenever a force, whether electrical or mechanical, causes motion, WORK is done. Naturally, we are speaking electrically, so let's take an electrical example. If we have a voltage, or difference in potential, existing between two points in an electrical circuit and we connect a conductor between these two points, electrons will flow. We are causing motion; therefore, work is done. We call this work, POWER. Power is measured in WATTS (W) and is the product of current and voltage. In other words, if we were to raise either the current or the voltage between those two points, power would increase. This can be expressed as a formula: P = I x E. In this formula, Power (P) is obtained by multiplying current and voltage (I and E). This formula never changes although it is not the only one we may use to find power.

Let's carry our description of power further in order to better understand it. It is important to understand that a given number of electrons may be moved from one point to another in 1 second or 1 minute, depending upon the rate at which they are moved. In either case, the total work done would be the same, only the rate changed. Let's take an example of 1 amp of current flowing with a difference in potential of 5 volts. If we apply the formula of P = I x E, then the answer would of course be 5 watts. So the RATE of electrical power used is 5 watts. Now let's increase the current flow, or, the number of electrons that we're moving between the same two points at the same voltage level. Let's increase the current to 3 amperes. Once again we use the formula of P = I x E, and the answer is now 3 x 5 = 15 watts of electrical power used in the same amount of time that we used 5 watts before. Therefore, the rate of power increased when we increased current. We could have increased voltage with the same effect.

Power is a function of current in that, as we vary current in any circuit, power varies directly with it. The same could probably be said to be true of voltage. As we vary voltage, power varies directly with it. The important thing to remember here is that power plays an important part in communications equipments, antennas, and electrical devices.

Electrical lamps and soldering irons are examples of electrical devices that are rated in watts. The wattage rating of these devices indicates the rate at which they convert electrical energy into another form of energy, such as light or heat. For example, a 150-watt bulb will produce a brighter light than a 100-watt bulb simply because it converts more energy into light.

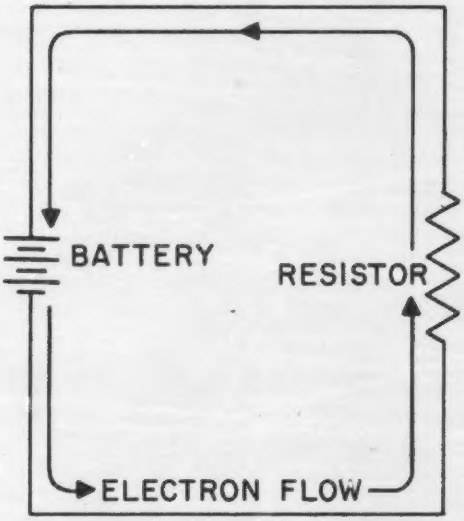
Soldering irons usually have a power or wattage rating. The higher the wattage rating, the more energy that the iron converts into heat than one of a lower wattage rating. These wattage ratings of electrical devices normally indicate the safe operating limits. Exceeding these limits usually causes damage to the device itself or may be hazardous to you during operation.

INTRODUCTION TO DIRECT CURRENT

Electric current is classified into two types: DIRECT CURRENT (d.c.) and ALTERNATING CURRENT (a.c.). Alternating current (a.c.) will be discussed later in this chapter. Direct current (d.c.) is current which flows in one direction only. This direction, of course, is from the negative to the positive side of the source. In most of the illustrations in this portion of the chapter, we will simply use a battery to represent the source voltage of the circuit.

In our study of direct current (d.c.), we will be calculating the various voltage, current, resistance, and power values. Our study will also include what is known as SERIES and PARALLEL circuits. So before we continue, let's define both of these terms.

SERIES CIRCUIT—A circuit that contains only one path for current to flow. Figure 2-9 shows a simple circuit showing the source as a battery.



76.83

Figure 2-9.—Simple series circuit.

Current will flow from the negative terminal, through the resistor shown and back to the positive side, or terminal, of the battery.

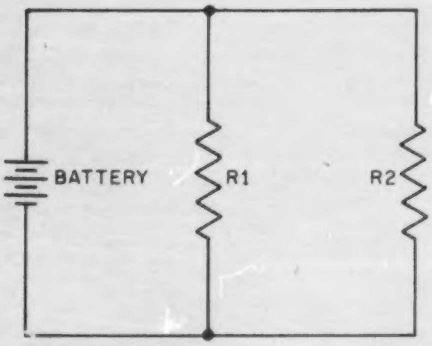
PARALLEL CIRCUIT—A circuit having more than one current path connected to a common voltage source. Figure 2-10 shows a basic parallel circuit, again using a battery as the source. There are two paths for current to flow: From the source, through each leg and resistor, and back to the source.

We will cover both types of circuits in this section and learn to solve them for the electrical values desired. We will begin the coverage of d.c. with series circuits and move on to parallel circuits later.

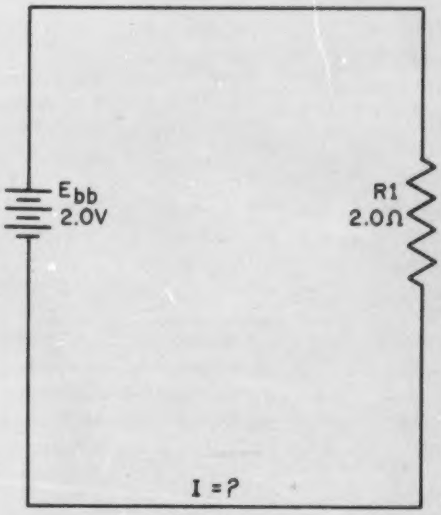
SERIES D.C. CIRCUITS

Current Calculation

In figure 2-11, we have shown a simple series circuit. We have a source voltage of 2 volts, a single path for current to flow through R1 whose value is 2 ohms, and back to the positive side of the source (Ebb). To determine the amount of current flowing in a series circuit is quite simple. All you need to do is to add each of the resistances around the circuit, and divide that figure into the total voltage. Let's take an example: using figure 2-11, we know what the total voltage is; it's 2 volts, the source voltage. The total resistance of the circuit is the resistance contained in R1, which is 2 ohms. Remember the formula $I = \frac{E}{R}$. You take resistance (2 ohms) and divide that into voltage (2 volts), and that will give you the current flowing in this particular series circuit. The answer, of course, is 1 ampere of current flowing.



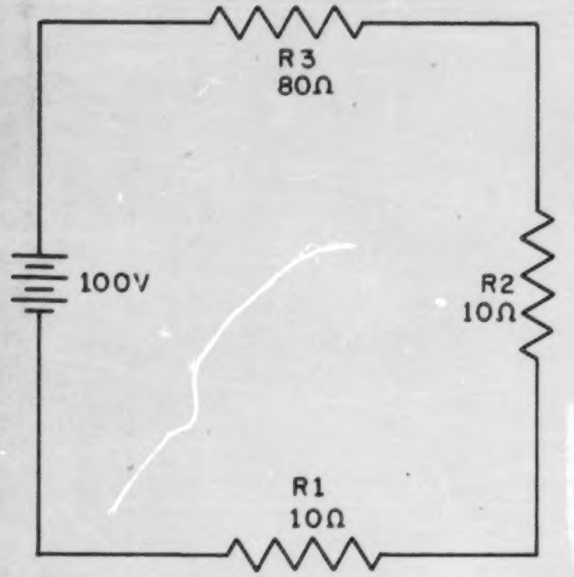
236.82
Figure 2-10.—Basic parallel circuit.



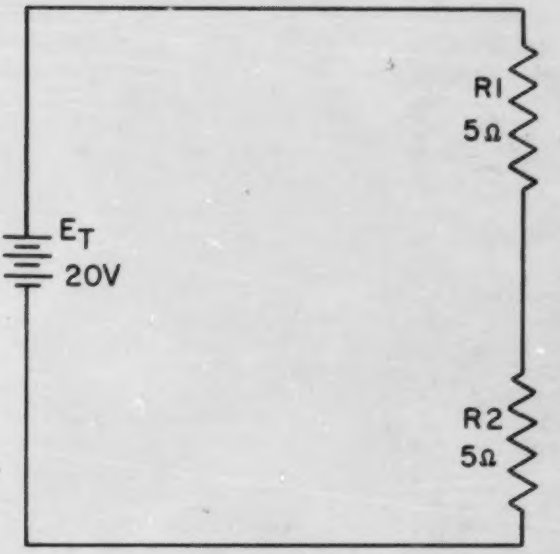
76.84
Figure 2-11.—Determining current (I) in a simple series circuit.

Now let's take another example and solve for current. Look at figure 2-12. You can see that it is basically the same as figure 2-11, the primary difference being that we have more resistors in the circuit. Don't let this confuse you, it is a simple matter of adding each of the values of resistance together and doing the same thing that you did in figure 2-11. Let's do it!

Again we use the formula, $I = \frac{E}{R}$. The source voltage (E) is 100 volts. The total resistance is 100 ohms (R1 + R2 + R3) or 10 + 10 + 80 = 100. Remember, in a series circuit, total resistance can be found by simply adding up all of the resistances, or, the total circuit resistance (RT) is equal to the sum of the individual resistances. As an equation, it would read; $R_T = R1 + R2 + R3 \ldots$etc. Again, we simply divide the total resistance (R_T) into the source voltage (which is also total voltage, E_T) and the answer is 1 ampere of current flowing in this series circuit.



236.59
Figure 2-12.—Solving for total resistance (R_T) in a series circuit.



236.62
Figure 2-13.—Calculating "voltage-drop" in a simple series circuit.

Since there is but one path for current to flow in a series circuit, the same current flows through each part of the circuit. You could actually determine total current (I_T) in a series circuit by solving for current in any one of the resistances contained therein. For example, in figure 2-12, we could have determined total current simply by finding the current through R1 or R2 or R3. Since it is a series circuit, the current is constant; that is to say that current is the same throughout any series circuit.

Voltage Calculation

Thus far, the total voltage (E_T) has been given to us in the form of source voltage. However, sometimes we may not know what the source voltage is, or we may be asked to prove that source voltage is indeed total voltage. First of all, a flat statement: Total voltage is equal to the sum of the individual voltage drops around a series circuit. Now there's a word that we haven't used yet: VOLTAGE DROP. What is a voltage drop? Look at figure 2-13. We have a simple series circuit with two resistors, each with 5 ohms of resistance, and a source voltage of 20 volts. First, let's find total current (I_T). This is done very simply by adding the two resistances, R1 + R2, or 5 + 5 = 10 ohms of resistance. Then, of course, we divide that figure into total voltage, $\frac{20 \text{ volts}}{10 \text{ ohms}} = 2$ amperes.). With total current (2 amps), we can find the individual voltages impressed across R1 and R2. Remember, current is constant in a series circuit.

We multiply the current times the resistance, or I x R, and that will give us the voltage impressed across R1. In this particular example, the current is 2 amps and the resistance at R1 is 5 ohms, therefore, 2 x 5 = 10 volts. This 10 volts is the "voltage drop" across R1. If we computed the voltage drop across R2, we would find that the answer would also be 10 volts "dropped" across it (2 amps x 5 ohms = 10 volts). We would also find that the combined total of these two voltage drops across R1 and R2 would equal our source voltage of 20 volts.

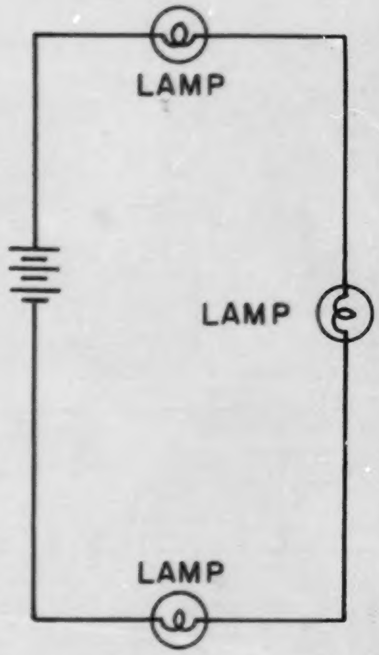
This serves to prove our original statement about total voltage being the sum of the individual drops around a series circuit. Therefore, total voltage (E_T) = E1 + E2 + E3 . . .etc. Although the source voltage was 20 volts in figure 2-13, the individual voltage drops at the various resistors use only part of that total in a series circuit. The amount that each resistance uses or drops, of course, depends upon its total resistance in relation to the other resistances. The higher the resistance of a particular resistor, the higher will be its voltage drop.

Resistance Calculation

When current (I) was discussed, you were introduced to resistance and how it was determined in a series circuit. Again, a flat statement: The total resistance (R_T) in a series circuit is equal to the sum of the individual resistances. As an equation, this could be written: R_T = R1 + R2 + R3 . . .etc. What is resistance exactly? We have already defined it as that quantity in a circuit that opposes current flow. But aside from that, what is a resistance? A resistance can be anything in a circuit that opposes current flow. When you plug in your table-lamp at home and turn it on, the lamp is the resistance in the circuit. Whenever you are using a soldering iron, the iron is the resistance in the circuit. As we said previously, resistance may be deliberately inserted into a circuit to accomplish a specific task for us, or it may be the primary user of energy in the circuit, sometimes referred to as the circuit LOAD. An example of this would be an electric typewriter. The typewriter is the prime user of energy in the circuit and is the very reason for having that particular circuit to begin with. Therefore, the typewriter would be referred to as the circuit load. It is the prime user and offers the major resistance in the circuit.

In Appendix II under the heading "Mechanical And Electrical Symbols", we have shown the schematic representation of a resistor. This schematic representation may indicate a natural resistance, such as those mentioned above, or they may represent man-made resistors deliberately inserted into a circuit to help us accomplish the task that the circuit is designed for.

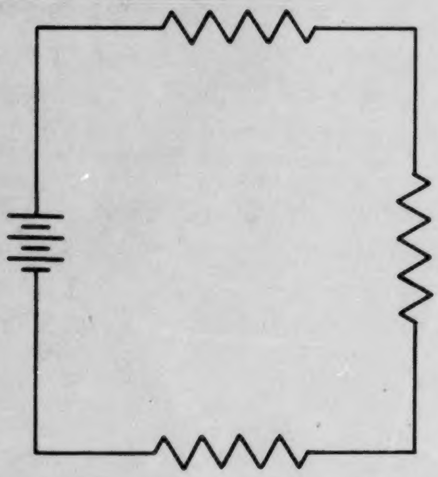
Look at figure 2-14. Here we have shown a series circuit with three lamps in series with each other. The lamps comprise the resistance of the circuit and are obviously meant to light whenever current passes through them. We could have expressed this circuit another way. Look at figure 2-15. This circuit is the same as figure 2-14, the only difference being that we have used the schematic representation of resistors in lieu of the schematic representation of a lamp.



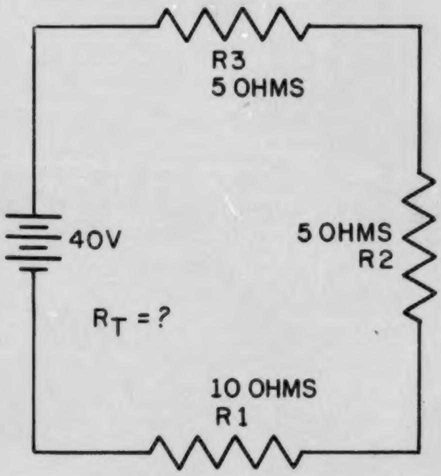
236.58
Figure 2-14.—Series circuit containing lamps.

Usually, when solving for resistance, we use the schematic symbol for a resistor to simplify things. Let's take an example of a series circuit containing resistance and find total resistance (R_T). Figure 2-16 shows a source voltage of 40 volts and three resistors of 10 ohms, 5 ohms, respectively. To find the total resistance, we need only add up the individual resistances of R1 + R2 + R3, or, 10 + 5 + 5 = 20 ohms.

We can also find total resistance (R_T) another way. If we knew total current (I_T), then we could find total resistance by simply dividing current into voltage: $\frac{E}{I} = R$, or $\frac{40\ V}{2\ A} = 20$ ohms. All we need is two of the circuit values, and



236.59
Figure 2-15.—Schematic representation of a resistive circuit.



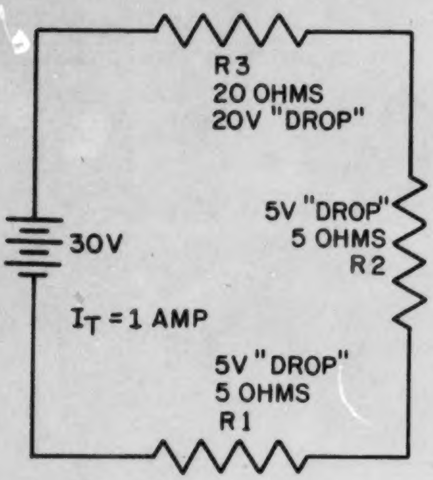
236.59
Figure 2-16.—Solving for resistance in a simple series circuit.

we can find the other. This is true of voltage, current, or resistance.

We can also compute the resistance of only one resistor in a series circuit. Using figure 2-17, we see the source of 30 volts and three resistors, R1, R2, and R3, respectively. R1 has a resistance of 5 ohms, as does R2. We have given that total current (I_T) is 1 amp. We have NOT been given the voltage drop across R3. Now, how would we go about finding the voltage drop across R3? First, take it step-by-step. We have given the resistance of R3 (20 ohms), and we have given the current of 1 amp in a series circuit. We can use the formula of E = I x R for individual components as well as for circuit totals. We know that current is constant in a series circuit. That means that 1 amp of current is flowing through R1, R2, and R3. So to find the voltage drop across R3, we simply multiply current times resistance, or, I x R, and that will give us voltage, E. You will sometimes hear the voltage dropped across individual components referred to as an "IR" drop. This is naturally derived from the equation shown above, since we multiply I and R to get E.

As you can see, we may use the basic equation to solve for voltage, current, or resistance values of individual components, such as resistors. You will find that this is done over and over again in solving electronic circuit values. Usually, any formula that we use to solve circuits for total voltage or total current or total resistance can be used to find the values of individual components as well.

Now let's refer back to figure 2-17. Let's assume that R3 has been given no value. We know that total voltage (E_T) is 30 volts and that the resistance of R1 and R2 is 5 ohms apiece. How would we go about solving for the resistance of R3? The answer is quite simple. The current is 1 amp and the total voltage is 30 volts. First, we have to find the individual voltage drops of each resistance. The reason for this is that we are going to have to find the resistance of an individual component, therefore, we need to have both E and I in order to solve for R. If we find the voltage drops of R1 and R2, then we will know the voltage drop on R3. By multiplying the constant current of 1 amp times the resistances of each resistor, we can determine the voltage drops across them. This is shown by multiplying 5 ohms times 1 amp, giving us an answer of 5 volts, or, I x R = E. Since both R1 and R2 are 5 ohm resistors, then the voltage drop across each of them will be 5 volts. Now, remember our axiom: The total voltage of a series circuit is equal



236.59
Figure 2-17.—Multiple calculations in a simple series circuit.

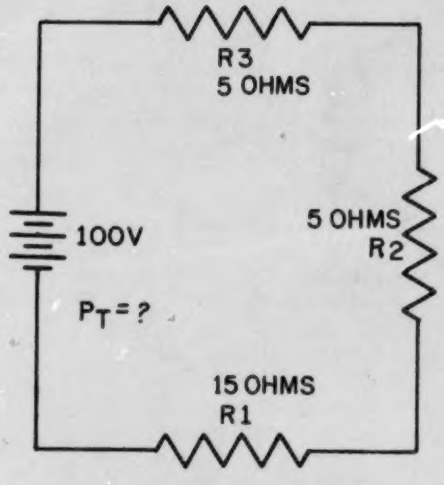
to the sum of the individual voltage drops around it. We know that the combined voltages of R1 and R2 equals 10 volts. We also know that the total voltage is 30 volts. Therefore, if we subtract 10 volts from 30 volts, then the voltage drop across R3 must be 20 volts. Now we know the current and the voltage of R3. To find the resistance of R3 now is a simple matter of applying the formula of $R = \frac{E}{I}$, or, dividing the current (I) of 1 amp into the voltage (E) of 20 volts, $\frac{20}{1} = 20$ ohms. That is the resistance of R3, 20 ohms. Remember, we solve for voltage, current, and resistance in components in the same manner as we do for the entire circuit. The only difference, of course, is that we are solving for totals when we are solving the entire circuit, whereas the values of individual components are for those components only. Remember also that you must have two values in order to solve for the third.

Power Calculation

In a series circuit, each resistance or resistor consumes power from the source. The resistors dissipate this power in the form of HEAT. Therefore, if each resistor consumes power from the source, then it stands to reason that we should be able to add the individual power drops around a series circuit just as we do voltage drops and obtain the total power (P_T) expended in the circuit. And that is exactly what we do.

The formula for finding power is $P = I \times E$. Where P is power, I is current and E is voltage. If we want to find power, we simply multiply current times voltage. If we want to find current, we simply divide voltage into power, or, $I = \frac{P}{E}$. If we want to find voltage, we simply divide current into power, or, $\frac{P}{I} = E$. So as you can now see, there are other ways to solve for current and voltage than the one we have been using thus far. Remember, this formula of $P = I \times E$ is constant and never changes. In view of this, we may now state the fact: The total power in a series circuit (P_T) is equal to the sum of the individual power drops around the circuit. This can be stated: $P_T = P1 + P2 + P3$ . . .etc.

Let's take a look at figure 2-18. Again, we have shown a series circuit containing a source and various resistances. The source voltage is 100 volts. R1 has 15 ohms of resistance, R2 has 5 ohms of resistance, and R3 has 5 ohms



236.59
Figure 2-18.—Solving for total power (P_T) in a simple series circuit.

of resistance. Solve the circuit for total power (P_T).

Always solve a circuit step-by-step. First, take the formula, $P = I \times E$. We know that in order to find total power, we must have total voltage (E) and total current (I). We have total voltage, which is 100 volts. Now all we need is total current. To find current all we need to do is divide total resistance into voltage, or, $I = \frac{E}{R}$. How do we go about finding total resistance, R_T? By adding the individual resistances around the series circuit, $R_T = R1 + R2 + R3 \ldots$ etc. or, in this particular circuit, R_T = 15 ohms + 5 ohms + 5 ohms = 25 ohms of total resistance in figure 2-18. Therefore, we can divide total resistance into total voltage and obtain total current, or, $I = \frac{E}{R}$. Therefore, $I = \frac{100 \text{ volts}}{25 \text{ ohms}}$, and I = 4 amps. Now that we have found total current of 4 amps, we can find total power. The power formula is $P = I \times E$. We have total voltage of 100 volts, and total current of 4 amps, therefore, $P = I \times E$, or, $P = 100 \times 4$, and P = 400 watts.

Just as we did with voltage, we can do with power. That simply means that we can use the power formula for individual components as well as for finding total values. For example, if you know the voltage drop across a resistor and the current flowing through it, then you can find the power expended by it. The only difference between the two is that you must have total values to find circuit totals; whereas, with individual components it is only the values of current or voltage or resistance for that component. This is a common error made by even experienced personnel. That is the reason for ensuring a step-by-step procedure when solving for circuit values.

Rules For Series Circuits

Thus far, we have talked about the basic values computed in series circuits. Often, it is difficult to remember basic guidelines, and this will become more apparent after we have covered a.c. theory. But in a.c. as well as in d.c. there are certain rules that may aid us in understanding and solving electronic circuits. We will cover rules governing a.c. at the end of that section in this chapter, but we may now take certain facts covered thus far dealing with d.c. circuits and consider them rules. These rules are:

1. Current is constant in a series circuit. The same current flows through all parts of a series circuit.

2. The total resistance of a series circuit is equal to the sum of the individual resistances.

3. The total voltage in a series circuit is equal to the sum of the individual voltage drops.

4. The voltage drop across a resistor in a series circuit is proportional to the electrical size of the resistor.

5. The total power dissipated or dropped in a series circuit is equal to the sum of the individual power dissipations, or drops.

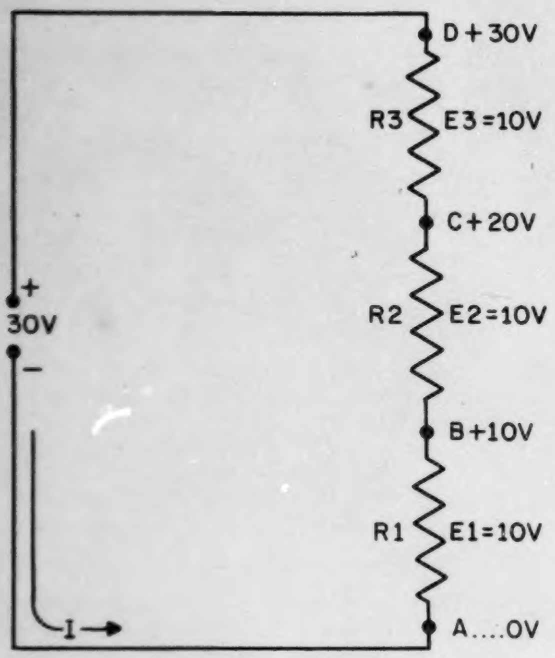
COMMONLY USED ELECTRONIC TERMS

Reference Points

A REFERENCE POINT is a chosen point in an electronic circuit to which all other points in that electronic circuit are compared. Look at figure 2-19. We have shown a simple series circuit with three resistances in series. Each resistor is of equal value, therefore the individual voltage drops across each one are equal. The source voltage is 30 volts, the arrow indicates the direction of current and we have 10 volts dropped across each resistor.

Normally, in electronic circuits, the reference-point used is GROUND. Ground is normally what everything is referenced to. In figure 2-19, point "A" is going to be the reference point, and for the sake of realism, we will assign it a potential of zero volts. This is because ground is normally zero volts.

Everything that we measure in this circuit will be in reference to point "A". If we were to measure from point A to point B, we would find that point B is 10 volts more positive than point A. If we were to measure between point A and point C, we would find that point C is 20 volts more positive than point A. If we measured between point A and point D, we would find that point D is 30 volts more positive than point A. We could go on and on with other resistive values, and we could even change our reference point, but by now you can see the usage of a reference point.



236.73
Figure 2-19.—Reference points in a series circuit.

Ground

As we mentioned in the previous topic, ground is normally the reference point in electronic circuits. Since the earth is said to be at a zero potential, the term ground is used to denote a common electrical point of zero potential. In most equipments, the metal chassis is normally the common ground for the circuits contained inside the equipment.

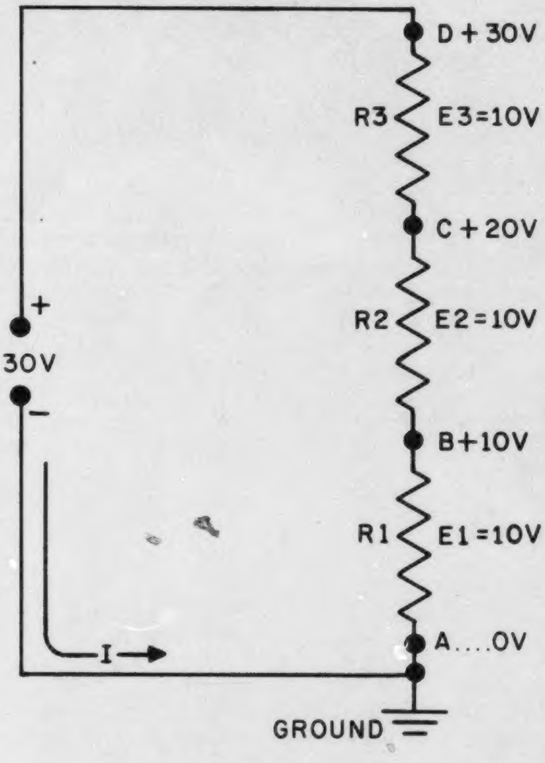
There are many benefits to the method of using ground: It contributes to economy, simplifies schematics, and makes it easier to make measurements. Most circuits have common points at zero potential and are connected directly to the metal chassis of the equipment, thereby eliminating long connections when measurements are made.

Most voltage measurements used to check proper circuit operation in electronic equipments are taken with respect to ground. This is normally done with one meter lead attached to ground and the other lead is used to check various test points in the circuit. We will cover these procedures in greater detail in the chapter entitled: "Basic Test Equipment".

In figure 2-20, we have shown essentially the same material shown in figure 2-19. The values are the same, but we have added the designation for "ground" under point A. This is the symbol used in schematics and means the same thing at all times: ZERO POTENTIAL.

Open Circuit

A circuit is said to be OPEN when a break occurs in a complete conducting path. We open a circuit whenever we throw a switch that de-energizes a circuit. However, an open may happen accidentally due to some abnormal condition. Normally, to restore a circuit to proper

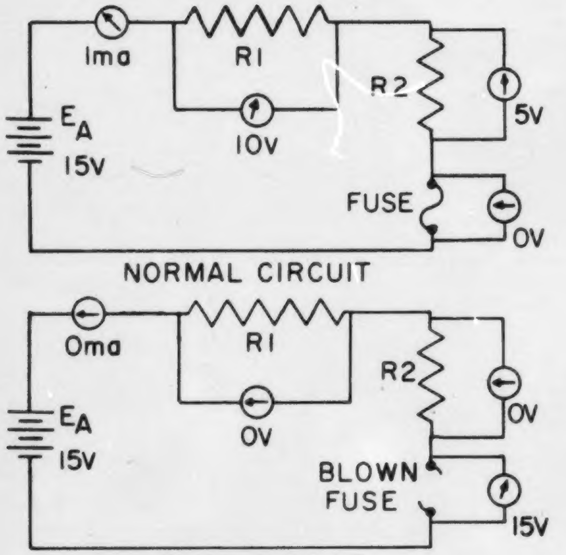


236.73
Figure 2-20.—Ground symbol in an electrical circuit.

operation after an open occurs, the open must be found and the cause determined.

Determining the cause of an open circuit may be very simple, or it may be quite complex. Sometimes an open may be located visually by inspecting the circuit components thoroughly. Defective components, such as burned out resistors, capacitors, fuses, etc., can usually be discovered via this method. Other opens, such as a break in a wire that is covered with insulation, are not visible to the eye. In that event, proper knowledge and usage of the applicable test procedures and equipments is necessary.

In figure 2-21, the series circuit consists of a fuse, two resistors, and the source voltage. Look at the circuit values of current and voltage in the "normal circuit". Now notice the effects of the open fuse in the "open circuit". Notice that current ceases to flow; therefore, there is no longer a voltage drop across the resistors. Each end of the open conducting path becomes an extension of the battery terminals and the voltage measured across the open equals the source voltage.



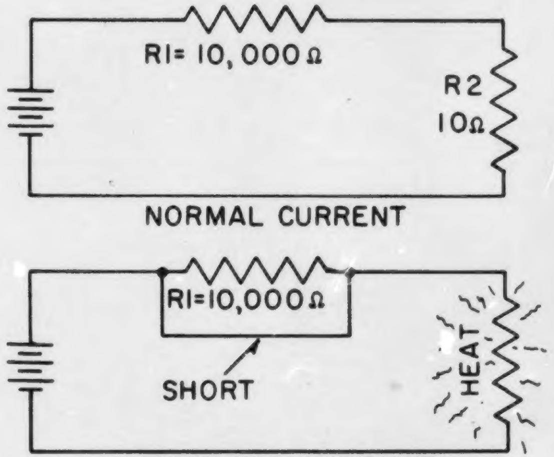
236.77

Figure 2-21.—Normal circuit and open circuit.

Short Circuit

A SHORT CIRCUIT is an accidental path of low resistance which allows an abnormally large amount of current to flow. A short exists whenever the resistance of the circuit or the resistance of a part of a circuit drops in value to almost zero ohms. A short may occur as a result of improper wiring, broken insulation, pieces of sl[illegible]ings or wires touching between a component and ground, or any number of things that would be much too lengthy to mention here.

Something that has not been mentioned yet is that current always seeks a path of least resistance. Just what is meant by this? Look at figure 2-22. In the upper part of the figure, annotated "Normal Current", we have shown the circuit in its normal state. Current flows from the battery source, through R2, through R1 and back to the source. Now, in the bottom part of the figure, annotated "Abnormal Current", we have simply taken a wire and connected it into the circuit at either end of R1. Current flowing out of R2 will take the path through the wire instead of through R1 because of the lesser resistance offered by it. In effect, we have "shorted" the current around the resistor. Now let's analyze the effects of this action on the circuit as a whole.



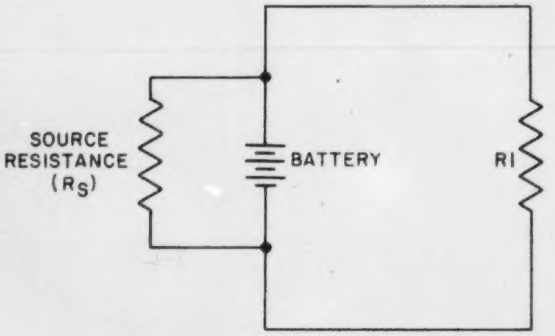
236.79

Figure 2-22.—Short circuit conditions.

What we have done is simulate a short circuit. When a component shorts out in the manner which we have shown here, the overall resistance of the circuit is lessened. In other words, instead of the 10,010 ohms of resistance shown in the "normal current" schematic of figure 2-22, we have effectively reduced the circuit resistance to approximately 10 ohms, shown in the "abnormal current" schematic of figure 2-22. What will happen when we have a severe reduction in circuit resistance? Current increases because it no longer "sees" the resistance opposing it that was present before the short occurred. The sudden surge of current through the smaller resistor of 10 ohms will cause such a rise in heat in it, that it will "burn-up", or effectively be destroyed. This is the real danger to equipment whenever shorts occur. The sudden increase in current will destroy or damage many components and render the equipment useless. This is the reason that we have FUSES in equipments. If shorts occur, the increase in current will burn out the fuse, thereby opening the circuit, and current will cease to flow. This protects the equipment and gives us a chance to find the problem and correct it without damaging many major components.

Source Resistance

SOURCE RESISTANCE is the internal resistance of the voltage source. For example, whenever we use a battery as the voltage source in a circuit, the battery itself offers some resistance to current flow. Take a look at figure 2-23. We have shown another simple series circuit. The voltage source is a battery and current flows from the battery, through R1, back to the positive terminal of the battery, and through the battery, (from the positive terminal to the negative terminal), and back out into the circuit. When the current flows through the source, there is some resistance offered it by the inside of the battery itself, through its electrolyte. It stands to reason that this resistance can be measured and does affect the total resistance of a circuit. The resistance, which we have shown by drawing a resistor parallel to the battery, is usually very small and does not have a large effect upon circuit current, but it does affect it somewhat. This is what is known as source resistance.



76.85

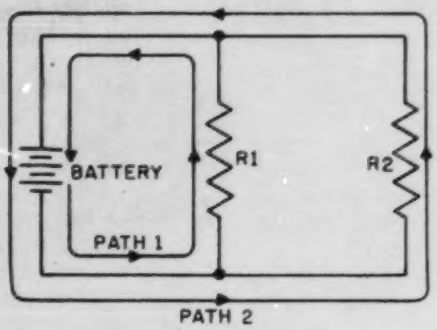
Figure 2-23.—Representation of source resistance.

PARALLEL D.C. CIRCUITS

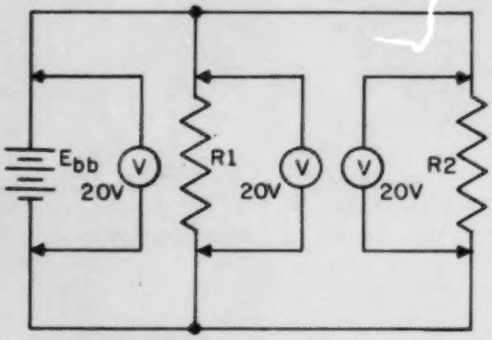
So far, we have concerned ourselves entirely with series circuits. An understanding of series circuits is, of course, essential. You will find that most of the electronic equipments that you come into contact with do contain series circuits. You will also find that most of the electronic equipments that you will come into contact with contain more parallel circuits than series circuits. Now that you basically understand what a series circuit is and how we solve for the more basic values of current, voltage, and resistance, we can move on to parallel circuits. Solving for basic values in a parallel circuit is not necessarily harder than a series circuit, merely different. Just as we had basic rules to abide by in series circuits, we have them in parallel circuits as well, and it requires only that we know and use them. First, let's define a parallel circuit. A PARALLEL CIRCUIT is defined as a circuit having more than one current path connected to a common voltage source. Figure 2-24 is an example of a parallel circuit. We have shown here a battery voltage source, two resistors in parallel (R1 and R2), and two paths for current to flow which are shown by the arrows (path 1 and path 2).

Voltage Calculation

In a series circuit, voltage divided proportionately across each resistor. In a parallel circuit, however, voltage is the same across all resistors of a parallel group. Voltage is probably the easiest value to obtain in a parallel circuit. In figure 2-25, we show a voltage source and two parallel legs containing R1 and R2, respectively. R1 is in parallel with R2 and both



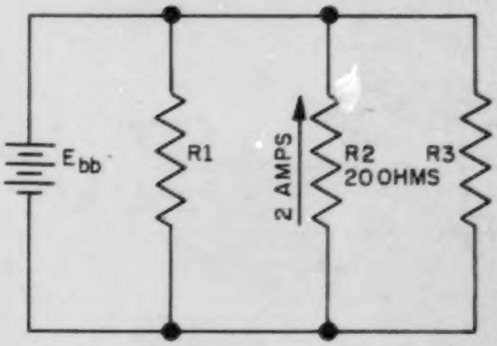
236.82
Figure 2-24.—Basic parallel circuit.



236.83
Figure 2-25.—Source voltage impressed across all parallel resistances.

are in parallel with the source of 20 volts. In this particular situation, as they are all parallel to each other, the voltage-drop impressed across each resistor would equal source voltage. Therefore, we would have 20 volts impressed across R1 and R2.

Now, how can this knowledge of constant voltage help us? Let's take another example. In figure 2-26, we have a simple parallel circuit. We have a source, three resistors in parallel, and the value of current in one leg. We have assigned R2 the value of 20 ohms of resistance and show current in that parallel leg to be 2 amps. We do not know what the source voltage is. But we do know what the current and resistance are in the second parallel leg; so we can find the voltage drop across R2. By using the formula of E = I x R, can find the voltage dropped across R2. Remember that we can use



236.84
Figure 2-26.—Finding source voltage in a parallel circuit.

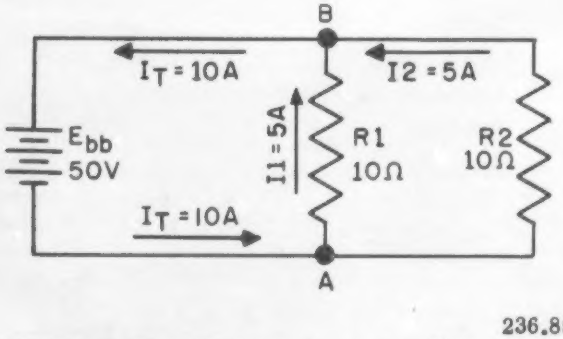
any of the formulas for individual components as well as for total values in a circuit. So let's take the current of 2 amps and multiply by the resistance of 20 ohms in R2 (E = I x R). Of course, this is equal to 40 volts (20 x 2). Now that we know the voltage drop across R2, we know the drops across R1 and R3, and what the source voltage is. Why? Because voltage is constant in a parallel circuit. ALL of the voltages will be 40 volts. So, as you can see, if you can find the voltage across any one leg or resistor in a parallel circuit, you know the source voltage as well as the voltage impressed across all parallel branches.

Current Calculation

As you know, current in a circuit is inversely proportional to resistance. The higher the resistance, the less the current. The lower the resistance, the higher the current. This never changes, regardless of the type of circuit. This is just as true of parallel circuits as it was of series circuits. However, there is a slight difference in the way current is computed in a parallel circuit as compared to a series circuit.

In a series circuit, the current was constant in that it was the same throughout. However, in a parallel circuit, current divides among the parallel paths in relation to the value of the resistance (or resistors) in each leg. In figure 2-27, we have shown a parallel circuit with a source of 50 volts, two parallel legs consisting of R1 and R2, and a total current of 10 amps. We can determine the amount of current flowing through each resistor by using the formula, $I = \frac{E}{R}$. We can use the source voltage to solve for each leg. Voltage is constant. Therefore, for R1, $\frac{50 \text{ Volts}}{10 \text{ Ohms}}$ = 5 amps of current flowing through R1. We can use the same formula to solve for the current flowing through R2. As you can see, the values of R1 and R2 are the same, so the current flowing through each will be the same: 5 amps. The total current in this circuit is 10 amps. Total current is always equal to the sum of the individual currents of the parallel legs in a parallel circuit.

Let's take one more look at figure 2-27 and trace current around the circuit. The total current of 10 amperes leaves the negative terminal of the battery and flows toward point "A". Point A is a connecting point for the two resistors and is called a JUNCTION. At junction A, the total current divides into two smaller currents of 5 amps each. (Bear in mind at this point that the two currents are equal ONLY because the resistance of the two legs are equal. If the resistors of the two legs were of different ohmic values, the current would have divided accordingly with more current flowing through the lower value resistance and less current flowing through the higher value resistance.) These two currents flow through their respective resistors and are rejoined at junction B. The total current of 10 amps then flows from junction B back to the positive terminal of the battery. Thus, the battery supplied a total current of 10 amperes, and each of the two equal resistors carried half of the total current.

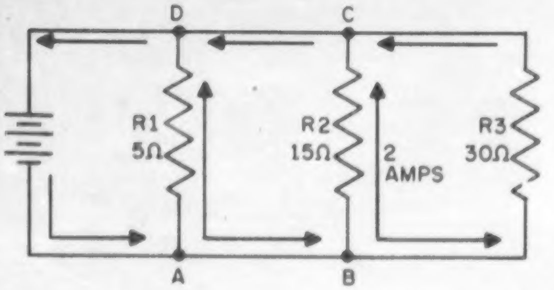


236.85
Figure 2-27.—Current in a parallel circuit.

Let's try it again using a different circuit. Take a look at figure 2-28. Here, we have a parallel circuit with three legs instead of two. Don't let this confuse you. Solving for three legs is as easy as solving for two legs. Solving for four or five legs would be just as easy. Remember the basic laws: voltage is constant and current divides proportionately. In this figure, we have not given the source voltage or the total current. We have R1 of 5 ohms, R2 of 15 ohms, and R3 of 30 ohms of resistance. Given is the current through R2, the second leg (2 amps). In order to find the voltage drop across each resistor, or the total voltage, all we have to do is to find it across any one resistor. In our second leg, containing R2, we know that the current is 2 amps and the resistance is 15 ohms. We have two of the necessary values, so we may now solve for voltage across it by applying the formula: $E = I \times R$. By multiplying the current times the resistance, we can solve for the voltage drop across R2. Therefore, we would multiply 15 ohms x 2 amps = 30 volts.

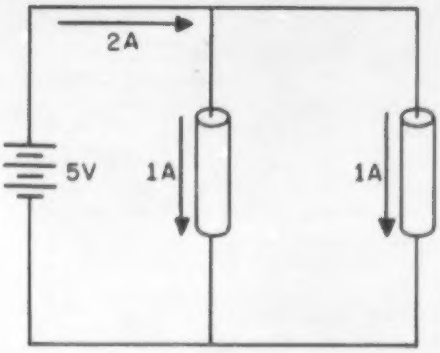
Now that we know the voltage drop across R2, we know the voltage drop across R1 and R3 and the source, since they are all in parallel with each other. They are all 30 volts. We may now solve for the individual currents in each leg by dividing the resistance of each leg into the voltage dropped across it, or $I = \frac{E}{R}$. In the leg containing R1, the current would be $\frac{30 \text{ Volts}}{5 \text{ Ohms}}$ = 6 amps. In the leg containing R3, the current would be $\frac{30 \text{ Volts}}{30 \text{ Ohms}}$ = 1 amp. Therefore, the total current would be the sum of all the individual legs, or, 6A + 2A + 1A = 9 amps total current.

Let's trace the current around the circuit again. The total current of 9 amperes leaves the negative terminal of the battery and flows toward junction A. At junction A, 6 amps flow through R1 and the remaining 3 amps flow toward junction B. At junction B, 2 amps flow through R2 and the remaining 1 amp flows through R3. At junction C, the currents flowing from the two parallel legs containing R2 and R3 combine into 3 amperes and flow toward junction D. At junction D the 3 amps flowing from junction C combine with the 6 amperes flowing from the leg containing R1, and the total current of 9 amps flows back to the positive terminal of the battery.



236.86

Figure 2-28.—Current division in a parallel circuit (3 legs).



236.89

Figure 2-29.—Two parallel resistors of equal value.

Resistance Calculation

Probably, one of the hardest things to understand for most people is calculating parallel resistances. In actuality, it really isn't hard. One of the common mistakes made by most is that they do not take it one step at a time when solving for parallel resistances. We will learn several methods for solving parallel resistances. Each method is relatively simple and totally accurate.

First of all, let's take a simple parallel circuit containing two resistors in parallel, as shown in figure 2-29. We have shown a 5 volt source with a total current of 2 amps flowing through two resistors. Each resistor is drawing 1 ampere of current. Common sense could probably tell you that if each resistor is drawing the same amount of current, then the two resistors must both be of the same ohmic value. But not only must we be able to mentally compute this; we must also be able to show why. So let's continue.

Since we know total voltage and total current, it is a simple matter to find total resistance with the formula $R = \frac{E}{I}$. Using that formula: $R_T = \frac{5 \text{ volts}}{2 \text{ amps}}$ or, $R_T = 2.5$ ohms. Also, since we know the voltage across each resistor (5 volts), we can find the resistance of each resistor by dividing the voltage dropped across each leg by the current flowing through each leg. In this case, we use the formula: $R = \frac{E}{I}$, or, $R = \frac{5 \text{ volts}}{1 \text{ amp}} = 5$ ohms, the resistance for R1 The same would be true of R2 since they both have the same amount of current flowing through them.

We could have found total resistance in another way. We could have divided the ohmic value of one resistor by the number of resistors. To explain, anytime that the resistors in a parallel circuit are of equal value, you need only divide the number of resistors into the value of one of them. This will give you the total resistance of the circuit, but ONLY when the resistors are of equal value. Referring back to figure 2-29, once we determined that the resistors were of equal value, we could have taken the number of resistors (two) and divided that number into the ohmic value of either R1 or R2. Example: $\frac{5 \text{ ohms}}{2 \text{ (no. of resistors)}} = 2.5$ ohms total resistance. It would not have mattered if we had 2, 3, 4, or more legs in the circuit. If they were of equal resistances, the method could still be the same. Therefore, we could make a formula from this that would apply whenever parallel legs are of equal value:

$$Req = \frac{R}{N}$$

where

Req = equivalent parallel resistance
R = ohmic value of one resistor
N = number of resistors

The term EQUIVALENT RESISTANCE is a term used in determining parallel resistance. This word is used due to the fact that we do not obtain total resistance in parallel circuits by adding up the individual resistances as we did in series circuits. We speak of the resistance in a parallel circuit as the overall resistive effect of all resistances. This should not be confused with "average" resistance because we don't take the average of all resistances shown in a parallel circuit. The example shown in figure 2-29 is unique in that the resistances were equal, but that is the exception, not the rule. Normally, of course, the resistances in a parallel circuit are of different values. Therefore, we solve for the equivalent resistance. Perhaps a simpler way of saying this would be to say, "take all of the resistances shown in a parallel circuit and combine them into ONE resistor that would show the overall resistive effect of all of them." This, therefore, would give us the equivalent resistance of the circuit.

Another method of solving for the Equivalent Resistance of two resistors in parallel is via the following formula: $\frac{R1 \times R2}{R1 + R2} = R_T$ this method is called the "product over the Sum". Remember, this formula should be used for two resistors in parallel, only. Using figure 2-30 as an example, we have a parallel circuit showing 30 volts source, 15 amps current, and two resistors of 3 ohms and 6 ohms each. In this particular example, because we have only two resistors, we may use the formula mentioned above:

$$R_T = \frac{R1 \times R2}{R1 + R2}$$

therefore:

$$R_T = \frac{3 \times 6}{3 + 6}$$

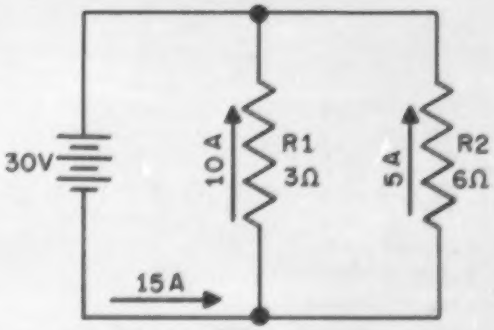
therefore:

$$R_T = \frac{18}{9}$$

and:

$$R_T = 2 \text{ ohms}$$

As you can see, this is a very simple method of solving for parallel resistance whenever you have only two resistances.



236.91

Figure 2-30.—"Product-over-sum" method for calculating two parallel resistances.

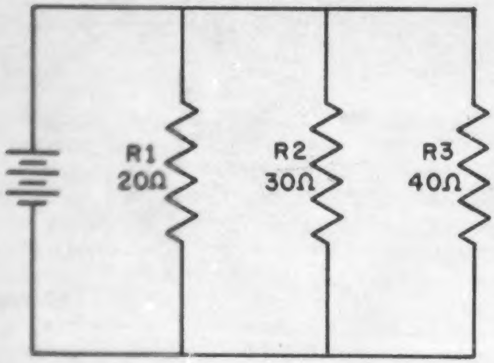
So far, you have learned how to compute parallel resistances that are equal in each branch, and two parallel branches of unequal value. One more method remains to be covered and this is the most commonly accepted method for solving parallel resistances of more than two legs that are of unequal values. This method is called the RECIPROCAL METHOD. It is probably the most confusing of the ones that we've covered so far, but it is no problem when taken step-by-step. The formula is,

$$R_T = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \frac{1}{R4} \ldots}$$

Let's take an example and solve it step-by-step. Look at figure 2-31. We have three parallel legs of resistance containing 20, 30, and 40 ohms respectively. So as to be less confusing, we will use the term "Req" (equivalent resistance) in the place of R_T. Now, let's select the proper equation for solving this circuit. That would be:

$$Req = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}}$$

Don't be confused by the supposed complexity of the equation. By placing all of the values under "1", we are simply saying that once we get our answer with a lowest common denominator, we must find the reciprocal.



236.92

Figure 2-31.—Solving for R_T by "reciprocal" method.

Substituting values:

$$\text{Req} = \frac{1}{\frac{1}{20} + \frac{1}{30} + \frac{1}{40}}$$

Now, in order to add fractions, we must find a common denominator for them. By that we mean, which number (lowest number) will all of the denominators (ohmic values) divide into evenly. In this particular case, the number is 120. So, using the lowest common denominator:

$$\text{Req} = \frac{1}{\frac{6}{120} + \frac{4}{120} + \frac{3}{120}} = \frac{1}{\frac{13}{120}}$$

The "1" over $\frac{13}{120}$ tells us that we must invert $\frac{13}{120}$. So, inverting:

$$\text{Req} = \frac{120}{13} = 9.23 \text{ ohms}$$

Sometimes, there is no lowest common denominator, and we must solve for Req via long hand. By "long hand" we mean that we must divide the equation out. To explain this, let's take the same circuit (figure 2-31) and do it via long hand:

$$\text{Req} = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}}$$

Substitute:

$$\text{Req} = \frac{1}{\frac{1}{20} + \frac{1}{30} + \frac{1}{40}}$$

Dividing the denominators into their numberators of "1":

$$\text{Req} = \frac{1}{0.050 + 0.033 + 0.025}$$

Adding them up:

$$\text{Req} = \frac{1}{0.108}$$

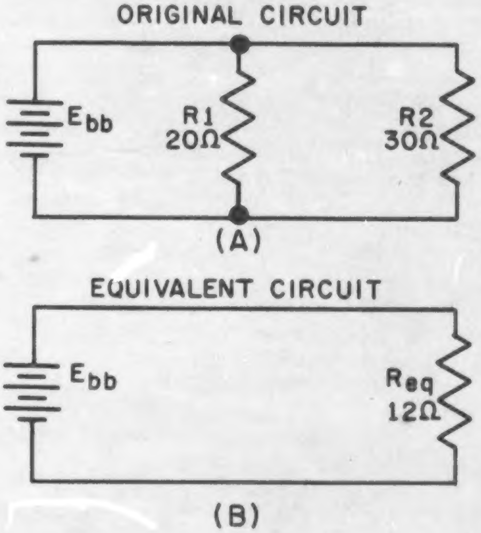
Dividing 0.108 into 1:

$$\text{Req} = 9.23 \text{ ohms}$$

This, of course, is more lengthy than finding the "lowest common denominator", but it may be used whenever no LCD is available.

Parallel Circuit Reduction

One of the things that you should try to do whenever you're solving parallel circuits is to try to simplify the circuit by condensing it down into a circuit that is easier to understand and solve. We can do that by "reducing" the parallel circuit to a series circuit wherever possible. Look at figure 2-32. What we have done is reduce a two-leg parallel circuit into



236.93

Figure 2-32.—Parallel circuit reduction.

a simpler, easier to understand, series circuit. We took the two legs of resistances, at 20 and 30 ohms respectively, and solved them for their equivalent resistance. Then we made one leg out of that, equal to the equivalent resistance of 12 ohms. (A) shows the original circuit; (B) shows the equivalent, or "re-drawn" circuit after computing the two parallel resistances. This is a very useful method to use for large series-parallel circuits with many paths for current to flow. By reducing the number of legs into as many series paths as possible, we can eliminate confusion and possible chances for error.

Power Calculation

To calculate power in a parallel circuit is the same as for a series circuit. We simply find the total power expended in the individual legs, and add them up. The formula for that again, is:

$$P_T = P1 + P2 + P3 \ldots$$

As in a series circuit, we may find the power expended across one resistor or the power expended in the entire circuit with the formula: $P = I \times E$.

Rules For Parallel Circuits

The following rules apply for parallel circuits. Remember them and apply them whenever solving for parallel circuit values:

1. The same voltage exists across each branch of a parallel circuit and is equal to the source voltage.
2. The current through a branch of a parallel network is inversely proportional to the amount of resistance of the branch.
3. The total current of a parallel circuit is equal to the sum of the currents of the individual branches of the circuit.
4. The total resistance of a parallel circuit is equal to the reciprocal of the sum of the reciprocals of the individual resistances of the circuit.
5. The total power consumed in a parallel circuit is equal to the sum of the power consumptions of the individual resistances.
6. The equivalent resistance of a parallel circuit will always be less than the smallest parallel branch, but only when all branches are parallel.

SERIES-PARALLEL COMBINATIONS

So far, we have discussed series circuits and parallel circuits. We have treated each one separately and learned the rules for solving circuit values of both kinds. However, as a technician making detailed circuit checks or as an operator making front panel adjustments, you will seldom, if ever, find a circuit that consists wholly of either type. Almost all circuits consist of series and parallel combinations. In solving series-parallel combinations, you need only apply the basic rules for both and proceed step-by-step. We will refer to these series-parallel combinations as COMBINATION CIRCUITS.

Solving a Combination Circuit

At least three resistors are required to form a combination circuit. In figure 2-33, we have shown a simple series-parallel circuit. The source is 20 volts, and the path for current flow is through R1 to junction b, the current divides at junction b and flows proportionately through resistors R2 and R3 of the parallel branch. The current joins at junction c and flows back to the source.

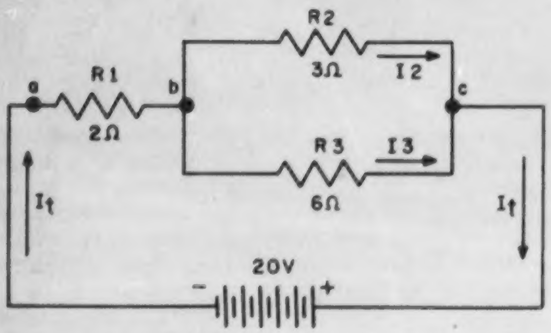
The easiest way to solve combination circuits is to solve parallel branches for total resistance (R_T) and re-draw the circuit in series, if possible. Let's do that with figure 2-33. In (A) of figure 2-33, we have the original circuit, and in (B) we have the re-drawn circuit, thereby making it easier to solve. In re-drawing it, we made a series circuit. We took R2 and R3, and solved for the equivalent resistance. Use the product over the sum method for two parallel resistors as follows:

$$Req = \frac{R1 \times R2}{R1 + R2}$$

Therefore, $Req = \frac{R2 \times R3}{R2 + R3}$ (from figure 2-33)

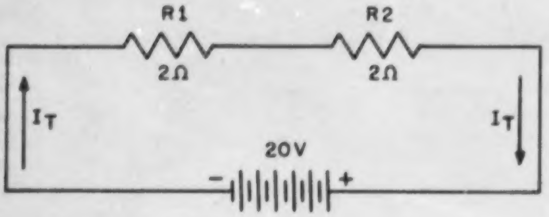
Therefore: $Req = \frac{3 \times 6}{3 + 6} = \frac{18}{9} = 2$ ohms.

After finding the equivalent resistance of R2 and R3, we can simply draw a 2 ohm resistor



R1 IN SERIES WITH PARALLEL COMBINATION OF R2 AND R3

(A)



RE-DRAWN CIRCUIT

(B)

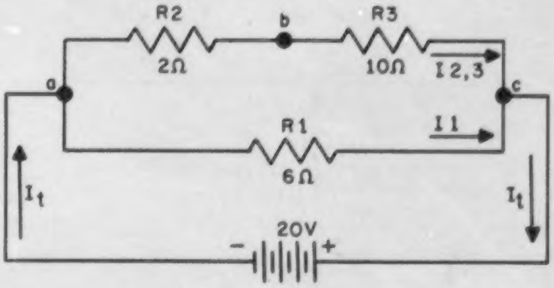
236.96

Figure 2-33.—Re-drawing and simplifying a parallel circuit.

in series with R1 and essentially have the same circuit, as is shown in figure 2-33 (B). This method is easier because it makes total resistance easier to solve for. In a series circuit, R_T = R1 + R2 + R3. . .etc. Therefore, R_T would be 4 ohms in the circuit shown in figure 2-33. We found that by adding up the resistances in series in figure 2-33 (B); R1 + R2 = 2 + 2 = 4 ohms. Making a series circuit also makes current easier to solve for because current is constant in a series circuit. In a parallel circuit of course, current divides and is harder to solve for. Essentially, what you're doing by re-drawing a series-parallel circuit is simplifying it by reducing it to fewer components, thereby making it less confusing and easier to solve. There is no formula for doing this with combination circuits, only that you apply the laws and rules you know for series and parallel circuits.

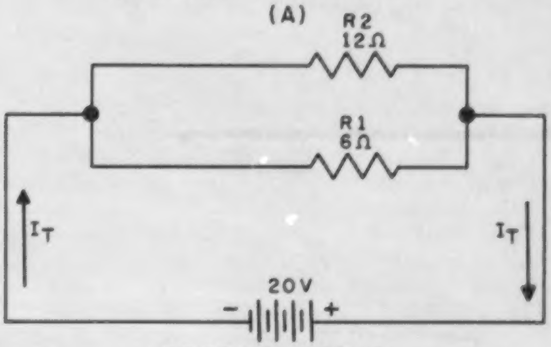
In figure 2-34, we have shown basically a parallel circuit, but, it is a combination circuit in that it has one leg with two resistances in series (R2 and R3). Again, the job is easier if we reduce the number of components that we have to solve for, thereby making the circuit less confusing. The easiest way to do this is to try to make one resistor out of R2 and R3 and solve for a parallel circuit, or, we can make one resistor out of the entire parallel combination of R1, R2, and R3. Let's do both. First, let's combine R2 and R3 and solve the circuit for R_T in parallel.

The leg containing R2 and R3 can be easily reduced using the law of resistances in series circuits since R2 and R3 are in series with each other and in parallel with R1. Since R2 and R3 are in series with each other, we can



R1 IN PARALLEL WITH THE SERIES COMBINATION OF R2 & R3

(A)



RE-DRAWN CIRCUIT

(B)

236.96

Figure 2-34.—Parallel circuit re-drawn and simplified.

combine them additively; R2 + R3 = 2 + 10 = 12 ohms. So we can now draw one resistor of 12 ohms in parallel with R1. This is shown in figure 2-34(B), where R1 = 6 ohms and R2 = 12 ohms. Once again, we have two resistors in parallel and can use the product over the sum method:

$$R_{eq} = \frac{R1 \times R2}{R1 + R2}$$

Therefore:

$$R_{eq} = \frac{6 \times 12}{6 + 12} = \frac{72}{18} = 4 \text{ ohms}$$

Actually, by solving the parallel circuit, we have now solved the second problem. Since R_t = 4 ohms, we could essentially draw one resistor of 4 ohms in place of R1, R2, and R3 in figure 2-34(A) and R1 and R2 in figure 2-34(B). Remember that by re-drawing combination circuits, you make it easier to find total values. If you have to find the values of individual components in the legs of the circuits, then you must use all of the rules and laws for series and parallel circuits that you have learned thus far. For a detailed description of individual component solving for series-parallel circuits, consult BASIC ELECTRICITY, NAVEDTRA 10086 series.

INTRODUCTION TO ALTERNATING CURRENT (A.C.)

In the study of d.c., we found that current flowed in only one direction. Certainly, d.c. has many applications in the many communications equipments that we use. However, in the overall picture of things, d.c. has many disadvantages which are apparent. In a d.c. system the supply voltage must be generated at the level required by the load. For example, to operate a 120-volt lamp, the generator, or source, must deliver 240 volts. An 80-volt lamp could not be operated from this generator, or source, by any convenient means. We could probably place a resistor in series with the lamp to drop the appropriate amount of voltage, but the resistor would consume a large amount of power, thereby eliminating the efficiency desired in the operation of electronic circuits.

Another disadvantage of d.c. systems is the large amount of power lost due to the resistance of the transmission wires used to carry current from the generating station, or source, to the loads. We could probably eliminate this by operating the transmission lines at higher voltages and lower currents, thereby getting less line-loss due to the higher currents. However, this would mean that the loads would all have to operate at a very high voltage value also, again, an undesirable characteristic.

We could go on and on discussing the difficulties of using d.c. in achieving circuit operations in the various equipments, but suffice to say that we don't. Practically all modern power distribution systems, both civilian and those on-board ship, use a type of current known as ALTERNATING CURRENT. Abbreviated a.c., alternating current flows first in one direction then reverses and flows in the opposite direction. Unlike d.c., a.c. has the ability to be "STEPPED-UP" or "STEPPED-DOWN", thus permitting transmission lines to be operated at a high voltage and low current for maximum efficiency by "stepping-up" the input, and at the user end it can be "stepped-down" again. Because of its inherent advantages and versatility, a.c. has replaced d.c. in most power distribution systems, such as commercial and shipboard systems. This power normally comes to all of us via the sockets that we plug our power cords into, both in our homes and in our work centers aboard ship. This power, usually from the ship's power plant, does no more than supply the initial power to operate our equipments. After we have supplied basic operating power from the ship's plant, the internal power supplies of the equipments furnish the various voltage and current supplies that are necessary for equipment operation. However, most of these internal power supplies are a.c. power supplies. The initial input is normally a.c. in communication equipments and, if need be, we can convert a.c. back into d.c. for proper operation of components contained in the equipments. Now, let's go into some of the terminology associated with a.c. and basically how we create a.c. currents and voltages.

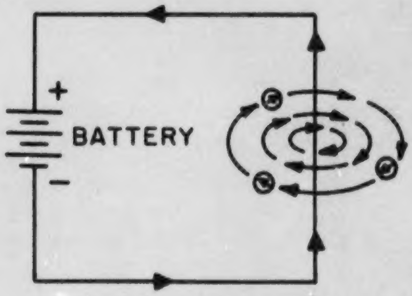
BASIC A.C. GENERATOR

There are many ways to create an a.c. current or voltage, but for simplicity's sake we will only consider the one easiest to understand and probably more familiar to all of us: The A.C. GENERATOR. An a.c. generator converts mechanical energy into electrical energy by using the principle of something we haven't discussed as yet; ELECTROMAGNETIC INDUCTION.

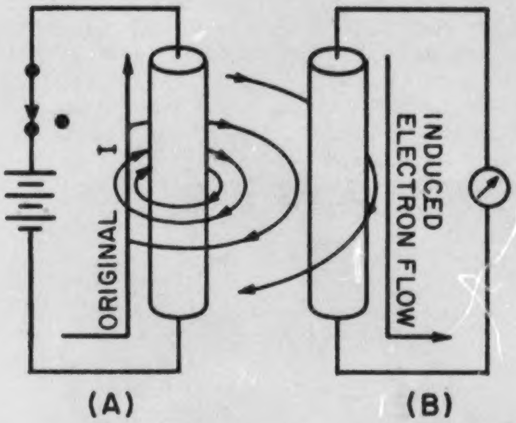
Let's briefly discuss electromagnetic induction and what it is. Whenever a current is passed through a conductor, a magnetic field is produced around that conductor. This magnetic field is physically real and can be measured. That is why we must shield such conductors that would affect other conductors close to it. This MAGNETIC FIELD is actually an emf, or voltage. In figure 2-35, we have shown a basic voltage source with a conductor making a complete path back to the source. As you can see, the magnetic lines of force caused by the current passing through the conductor extend outwards from the conductor. They are strongest immediately around the conductor and weaken as they get further from it. These magnetic lines of force, which are a physical emf, are called FLUX. These magnetic lines of flux are an integral part of electromagnetic induction and are the reason that electricity and magnetism are inseparable. Where you have one, you normally have the other or can create the other.

In figure 2-36, we have a piece of conductor that we have cut away from a conducting circuit and will assume that current is still flowing through it. We show the magnetic flux lines around it, and next to it we have another conductor close enough to be cut by the lines of force formed by the current. These lines of force, which we have called an emf and which is an actual voltage, will cause current to flow in the conductor being cut by the magnetic lines of force. This is indicated by the arrows in conductor "B". The current flowing in conductor "B" will flow in the OPPOSITE DIRECTION to that flowing in the original conductor. The reason for that is not important at the moment. The primary thing to remember is that the current flowing in conductor "B" as a result of the magnetic lines of flux emanated from conductor "A", is ELECTROMAGNETIC INDUCTION. We have actually "induced" a current in one conductor with the lines of flux of another conductor. So, with the knowledge that electromagnetic induction is used, let's continue with our discussion of a.c. generators.

A.c. generators are made in many different sizes, depending upon their intended use. Regardless of size, however, they all operate on the same principle—a magnetic field cutting through conductors, or conductors passing through a magnetic field. Thus, all generators have at least two distinct sets of conductors. They are (1) a group of conductors in which the output is generated, and (2) a second group of conductors through which direct current is passed to obtain an electromagnetic field of fixed polarity. The conductors in which the output is generated are always referred to as the ARMATURE WINDINGS. The conductors in which the electromagnetic field originates are always referred to as the FIELD WINDINGS.



236.157
Figure 2-35.—"Flux" lines around a current-carrying conductor.



76.86
Figure 2-36.—Electromagnetic induction.

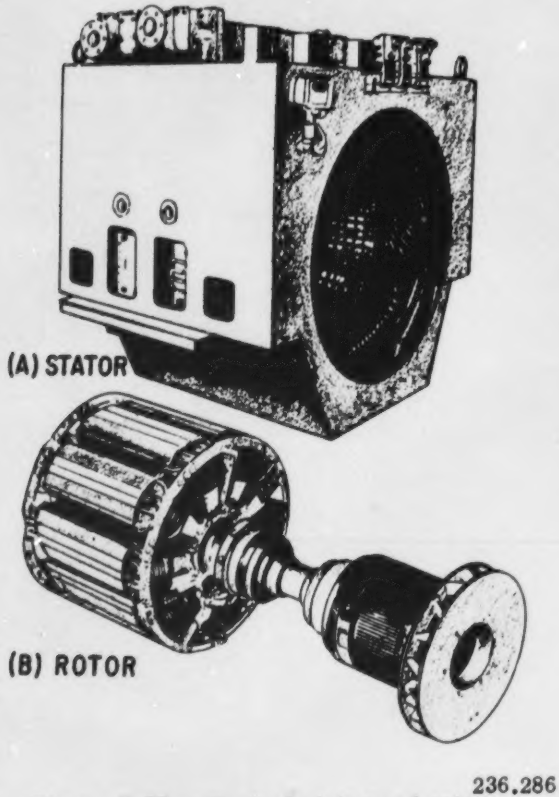
In addition to the armature and the field, there must also be motion between the two. To provide this, a.c. generators are built in two major assemblies, the STATOR and the ROTOR. The rotor rotates inside the stator. Figure 2-37 shows a typical stator and rotor. As was mentioned previously, in order to generate a.c., there must be motion between the stator and the rotor.

Types of A.C. Generators

There are various types of a.c. generators utilized; however, they are all similar in that they do the same thing: Provide a.c. The following two types are the more predominantly used:

REVOLVING ARMATURE.—In the revolving-armature a.c. generator, the stator provides the stationary electromagnetic field. By this, we mean that a small d.c. current is passed through the stator windings and a small electromagnetic field is built up around these windings. The rotor, acting as the armature, revolves in the electromagnetic field built up around the stator. When the rotor passes through the field built up around the stator and cuts the electromagnetic lines of force, or "flux", a current is induced into the windings, or conductors, of the rotor. A voltage, of course, is also induced into the rotor.

REVOLVING FIELD.—In this type, d.c. is passed through the windings on the rotor instead of the stator. This maintains a field of fixed polarity on the rotor. As the rotor turns inside the stator, the rotating magnetic field extends outward and cuts through the armature windings imbedded in the surrounding stator. As the rotor turns, alternating voltages and currents are induced in the windings since magnetic fields of first one polarity and then another cut through them. Now that we know what a.c. generators do, let's see how they do it.



236.286
Figure 2-37.—Typical stator and rotor.

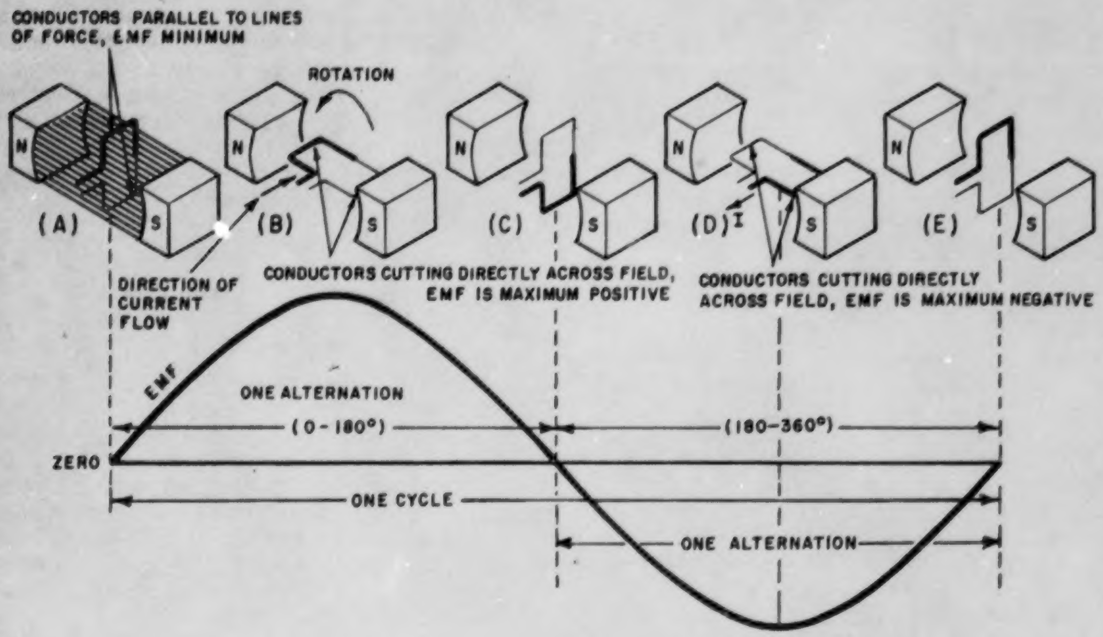
Generating A.C.

Figure 2-38 shows a suspended loop of wire (conductor) being rotated, or moved, in a counterclockwise direction through the magnetic field between the poles of a magnet. For ease of explanation, we have divided the loop into a dark and light half. Notice that in part (A), the dark half is moving parallel to the lines of force, or "flux" created by the North and South poles of the permanent magnet. The rotating loop must be imagined to be moving to your left, round and round. What we are going to do is take just ONE REVOLUTION of it.

In part (A), as the loop is moving temporarily parallel to the lines of force, it is cutting through very few of these force or "flux" lines. The same is true of the light half of the loop. Since the conductors are cutting few, or minimum, lines of force, MINIMUM emf is induced into these conductors.

As the loop rotates toward the position shown in part (B), it cuts more and more lines of force per second because it is cutting more directly across the field. At position (B), the induced emf is greatest because the conductor is cutting directly across the field.

Notice the WAVEFORM that we are plotting across the bottom of figure 2-38. We are representing the rise and fall of induced emf as the loop rotates. As the loop continues to be rotated toward the position shown in part (C), it cuts fewer and fewer lines of force per second. The induced voltage decreases from its peak value. Eventually, the loop is once again moving in a plane parallel to the magnetic field, and no voltage, or emf, is induced.


CONDUCTORS PARALLEL TO LINES OF FORCE, EMF MINIMUM
ROTATION
N
S
(A)
(B)
(C)
(D)
I
(E)
DIRECTION OF CURRENT FLOW
CONDUCTORS CUTTING DIRECTLY ACROSS FIELD, EMF IS MAXIMUM POSITIVE
CONDUCTORS CUTTING DIRECTLY ACROSS FIELD, EMF IS MAXIMUM NEGATIVE
EMF
ONE ALTERNATION
(0-180°)
(180-360°)
ZERO
ONE CYCLE
ONE ALTERNATION

236.171

Figure 2-38.—One cycle of generated a.c.

On the waveform plot, notice that the drawn form shows us starting at point (A), which was zero, and we proceeded to point (B), which was maximum, and then to point (C), which is back to minimum. The loop has now made one-half of a revolution.

When the loop is further rotated to point (D), the action is reversed. The dark half of the loop is moving UP instead of down and the light half is moving down instead of up. The polarity of the magnet remains the same, but the loop-halves, in changing their direction of travel, have changed the induced emf and current. It is now REVERSED. The voltage builds up to a maximum in this new direction (as shown by the bottom half of our waveform-plot). The loop finally returns to its original position (part (E), at which point the voltage is again zero. Therefore, the loop has completed one cycle. And that is exactly what we have plotted on the waveform-plot; ONE CYCLE.

A CYCLE, as shown in figure 2-38, is actually a circle because if you were to draw each half of the waveform and combine the two halves, you would form a circle, or 360-degrees. You will also hear a cycle referred to as a HERTZ. The term "Hertz" has been designated to be used in lieu of cycles-per-second. The primary difference between the two terms is that a cycle is referred to as one complete revolution in any period of time, whereas a Hertz is referred to as one complete revolution PER SECOND. The key to keeping these two terms straight is TIME.

Looking back at figure 2-38, you will notice the term "ALTERNATION" used on both the upper and lower part of the plot. One ALTERNATION is one-half of one cycle. It takes two alternations to make one complete cycle. When the loop moved from point (A) to point (C), one alternation, or one-half cycle has been completed. When the loop moved from point (C) to point (E), two alternations, or one cycle had been completed. You can also remember that one alternation is equal to 180-degrees, or one-half circle.

If the loop in figure 2-38 is rotated at a steady rate, and the strength of the magnetic field is uniform, the number of Hertz and the voltage will remain at fixed values. Continuous rotation will produce a series of waveforms like that shown in figure 2-38.

The waveform shown in figure 2-38 is called a SINE WAVE and is representative of one complete cycle of a.c. You will see the representative sine wave many times in your association with electricity and electronics. It is in the way shown in figure 2-38 that an a.c. generator converts mechanical energy into electrical energy. The rotating loop in figure 2-38 is, of course, called the armature and may have any number of loops or coils.

Frequency

As we saw when we examined the operation of a simple a.c. generator, one complete rotation of the loop produced one cycle of a.c. In electricity, we normally use the SECOND as the standard measure of time. We reference almost everything to 1 second of time. If one cycle is produced in one second of time, then it is said to have a FREQUENCY of 1. For example, in the operation of a simple a.c. generator loop in figure 2-38, if the loop made one complete rotation (from point (A) to point (E)) in one second of time, one cycle of a.c. would be generated. If we were to increase the speed of the loop so that one rotation required one-tenth of a second, then TEN cycles of a.c. would be generated. The number of cycles of a.c. that occur each second is called the FREQUENCY, and is symbolized by the letter (f).

The frequency of the a.c. generated by an a.c. generator depends on both the speed at which the armature rotates and the number of magnetic poles contained in the magnetic field. Regardless of the number of pairs of poles, a complete cycle of a.c. will be generated each time a North and South pole are passed in succession. Figure 2-39 shows a four-pole basic a.c. generator that is supplying a light bulb. In this generator, one complete rotation of the loop will produce two cycles of a.c. Since we have two North and two South poles, both the dark and the light-shaded portions of the loop shown in figure 2-39 will produce a cycle of a.c. apiece. There will be four reversals of current, or four alternations. In other words, two cycles of a.c. are generated for each mechanical revolution of the loop. If each revolution lasts one second, the frequency of the output is 2 Hertz. To find the output frequency of any a.c. generator, the following formula can be used:

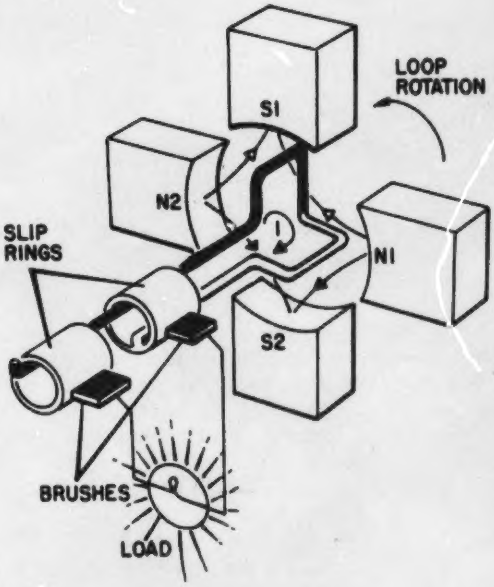
$$f = \frac{P \times rmp}{120}$$

where: f = Frequency in Hertz

rpm = Armature Revolutions Per Minute

P = Number of Poles

If an a.c. generator having two poles, was made to deliver 60 Hertz, it would need an armature designed to rotate at 3600 rpm. If the same generator had the two poles replaced with four poles, it would need an armature designed to rotate at 1800 rpm. In either case, the frequency would be the same.



236.172

Figure 2-39.—Basic 4-pole ac generator.

Period

As we mentioned earlier in this chapter, everything in the theory of electricity is in some way related to time. A cycle of a.c., or any sine wave, represents a definite amount of time. In figure 2-40, we have shown a sine wave whose cycle is twice in one second. Therefore, one cycle occurs every one-half second. The time required to complete one cycle of a waveform is called the PERIOD of the wave. In figure 2-40, the period is one-half second.

We plot waveforms on a single, horizontal line. This horizontal line is the reference point from which we show the variations in the changing values of voltage and current. Looking at figure 2-40, as current flows in one direction, we plot it above the horizontal line. This is the POSITIVE alternation of voltage or current. As current then changes direction and flows the other way, we plot it below the horizontal line. This is the NEGATIVE alternation of voltage or current. For a sine wave, these two alternations will be identical in size and shape, and opposite in polarity.

The period of a wave is INVERSELY PROPORTIONAL to its frequency. The higher the frequency, the shorter the period.

In terms of an equation:

$$t = \frac{1}{f}$$

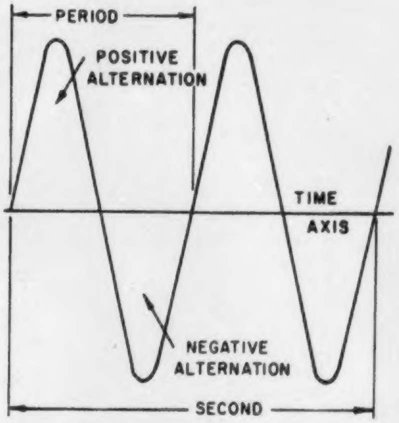
where: t = Period in Seconds
f = Frequency in Hertz

Sine Wave Amplitude

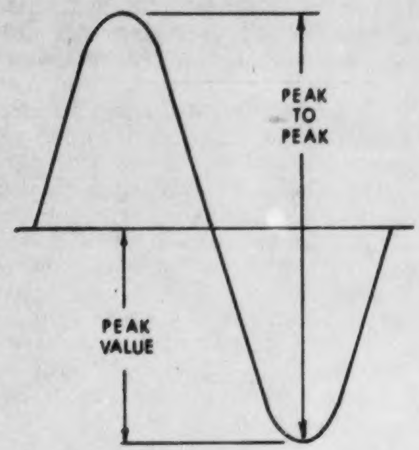
One of the most frequently measured characteristics of a sine wave is its amplitude. The amplitude of d.c. is relatively easy to measure because it is flowing at a constant rate, with little or no change in its amplitude. A.c., however, is always changing in value. As represented by the sine wave, it starts at zero, builds to a maximum on the positive alternation and then steadily decreases back to zero before beginning its negative alternation and repeating the process.

We must have some way of measuring a.c., otherwise we couldn't effectively utilize it. The amount of a.c. current or voltage present in a circuit can be measured in various ways. In one method of measurement, the maximum amplitude of either the positive or the negative alternation is measured. The value of current or voltage thus obtained is called the PEAK CURRENT or the PEAK VOLTAGE. To measure peak current or voltage, an oscilloscope or a special meter (peak reading meter) must be used. In figure 2-41, we have shown a sine wave plot. As the a.c. begins at zero and steadily builds to a maximum, it reaches its peak value. This is shown in the figure. Note that a sine wave has two peaks; one on the positive alternation and one on the negative alternation. This, of course, is because a.c. current changes direction, being positive during one-half of a period and then negative during the other half of the same period. The two maximum values of the positive and negative alternations are called the peak values of the sine wave.

Another method of measuring the amplitude of a sine wave is by determining the TOTAL value of current or voltage between the positive and negative peaks. Referring again to figure 2-41, this is called the PEAK-TO-PEAK value, and is shown. Since both alternations of a pure sine wave are identical, the peak-to-peak value is twice the peak value. Peak-to-peak values are usually measured with an oscilloscope, although



236.173
Figure 2-40.—The "period" of a sine wave.



236.176
Figure 2-41.—Peak and peak-to-peak values.

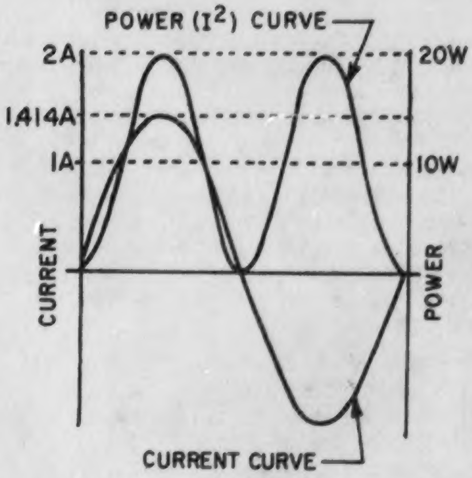
some voltmeters have a special scale calibrated in peak-to-peak values.

Effective or RMS Value

Perhaps by now you have noticed one of the less desirable characteristics of a.c.: It takes a larger peak value of a.c. to do the same job as a lesser level of d.c. To explain this, you know that a.c. builds from a minimum to a maximum, then back to minimum again. That means that we only realize peak value at the instant that it reaches its peak. At all other times during its period, it is of a lesser value than peak. D.c., on the other hand, reaches its peak value almost instantly and stays there. A 100-watt light bulb, for example, would be supplied more power from a 120 volts d.c. source than from an a.c. source with a peak value of 120 volts.

Since power dissipated by the lamp is a result of current flow through it, the problem then is one of finding a MEAN alternating current which would equal the same amount of d.c.

In a circuit in which a 10-ohm resistor is connected across an a.c. power source, the peak alternating current through the resistor is 1.414 amperes, as shown by the current curve in figure 2-42. Since the current through the resistor is changing continuously, the power dissipated by the resistor will also vary. It will be minimum when the current is zero.



236.178
Figure 2-42.—Peak-to-peak and effective values of a sine wave.

The variations in power throughout the cycle can best be analyzed by plotting a curve showing the instantaneous power at each point in the cycle. In the procedure to follow, the instantaneous current, the square of the instantaneous current, and the instantaneous power will be calculated in 10° steps for the first quarter of the cycle. These values are shown in table 2-1.

Notice that at 0° the instantaneous current (I) is zero causing the power dissipated by the resistor to be zero. At 10° the instantaneous current is 0.245 ampere, the current squared is 0.060, and the power is 0.60 watt. At 90° the current has reached its maximum value of 1.414 amperes, the square of the current is 2.000, and the power dissipated is 20.00 watts.

During the part of the sine wave of current from 90° to 180°, the same values could be used as before but in a reverse order. Thus, at 100° the values of current and power would be identical to those at 80°.

Using the values of I and P from table 2-1, a graph can be constructed showing the way in which power varies throughout the cycle. This graph is shown in figure 2-42.

In this graph a sine wave of current is plotted first, using the instantaneous values from table 2-1. Next the curve representing I^2 and power is constructed.

Notice that the power curve has twice the frequency of the current curve, and that ALL POWER IS POSITIVE. This is due to the fact that heat is dissipated regardless of which way the current flows through the resistor.

Since all the alternations of the power curve are identical, the MEAN or AVERAGE POWER is the value HALF-WAY between the maximum and minimum values of power. Thus, the average power dissipated by the 10-ohm resistor is 10 watts, one-half the peak power. Since the curve representing power also represents current squared (I^2), the average or mean of the curve also lies half-way between the maximum and minimum values of I^2. As power is proportional to I^2, a d.c. current having a value equal to the square root of the mean of the I^2 values would produce the same average power as the original sine wave of current. This mean current is called the ROOT MEAN SQUARE (RMS) current. One RMS ampere of alternating current is as effective in producing heat as one steady ampere of direct current. For this reason an RMS ampere is also called an EFFECTIVE ampere. In figure 2-42 the peak current of 1.414 amperes produces the same amount of average power as 1 ampere of effective (RMS) current.

Table 2-1.—Instantaneous values of current and power

Degrees	I	I^2	P
0°	.000	.000	.00
10°	.245	.060	.60
20°	.486	.236	2.36
30°	.707	.500	5.00
40°	.909	.826	8.26
50°	1.083	1.173	11.73
60°	1.225	1.500	15.00
70°	1.329	1.766	17.66
80°	1.393	1.940	19.40
90°	1.414	2.000	20.00

ANYTIME AN ALTERNATING VOLTAGE OR CURRENT IS STATED WITHOUT ANY QUALIFICATIONS, IT IS ASSUMED TO BE AN EFFECTIVE VALUE. Since effective values of a.c. are the ones generally used, most meters are calibrated to indicate effective values of voltage and current.

In many instances it is necessary to convert from effective to peak or vice-versa. Figure 2-42 shows that the peak value of a sine wave is 1.414 times the effective value and therefore:

$$E_m = E \times 1.414$$

where E_m = maximum or peak voltage
E = effective or RMS voltage

and

$$I_m = I \times 1.414$$

where I_m = maximum or peak current
I = effective or RMS current.

Upon occasion it is necessary to convert a peak value of current or voltage to an effective value. The conversion factor may be derived as follows:

$$E_m = E \times 1.414$$

Multiplying both sides of the equation by 1/1.414

$$E_m \times \frac{1}{1.414} = E \times 1.414 \times \frac{1}{1.414}$$

$$E_m \times \frac{1}{1.414} = E$$

Dividing 1 by 1.414

$$E = E_m \times 0.707$$

where E = the effective voltage
E_m = the maximum or peak voltage.

Similarly for current

$$I = I_m \times 0.707$$

where I = the effective current
I_m = the maximum or peak current.

Average Value

The average value of a completed cycle of a sine wave could theoretically be said to be zero. This is because the positive and negative alternations are equal in amplitude but opposite in polarity; therefore, mathematically, they cancel each other out. However, we can compute the AVERAGE value of ONE ALTERNATION. This is sometimes necessary in some electronics circuits. Basically, this is achieved by adding together a series of instantaneous values of the sine wave between 0 and 180-degrees, which is actually one alternation, or one-half of a circle of 360-degrees. We won't go into the method of computing all of these instantaneous values. We will only consider the result of this computation: One alternation of a sine wave has an average value equal to 0.637 of the peak value. In terms of an equation:

$$E_{avg} = E_m \times 0.637$$

where: E_{avg} = the average voltage of one alternation

E_m = the maximum, or peak voltage

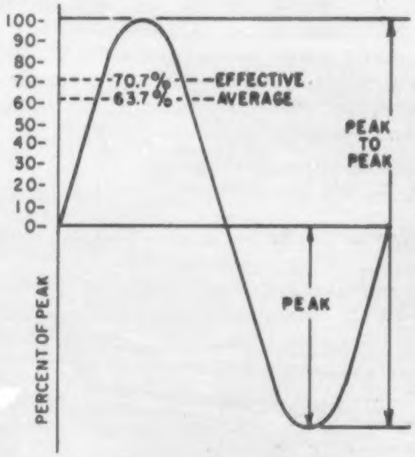
ALSO:

$$I_{avg} = I_m \times 0.637$$

where: I_{avg} = the average current in one alternation

I_m = the maximum, or peak current

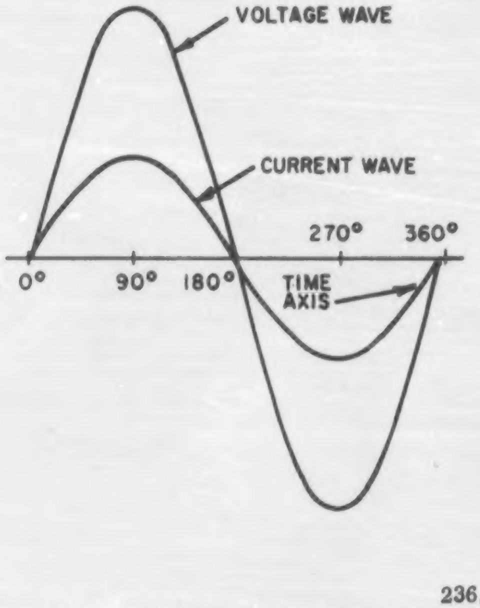
Figure 2-43 shows a comparison between the various values that are used to indicate the amplitude of a sine wave.



236.179
Figure 2-43.—Various values indicating amplitude of a sine wave.

Sine Waves in Phase

If we apply an a.c. voltage to a resistor, the resulting current will also be a.c. This is natural, of course, because current is a result of voltage or difference in potential. It follows, then, that current is directly proportional to the applied voltage. Figure 2-44 shows a sine wave of voltage and the resulting sine wave of current superimposed on the same time axis. Notice that as the voltage increases in a positive direction, the current increases along with it. When the voltage reverses direction, the current reverses direction. At all times the voltage and current values pass through the same relative parts of their respective cycles at the same time. When these two waves are in-step with each



236.180
Figure 2-44.—Voltage and current waves in-phase.

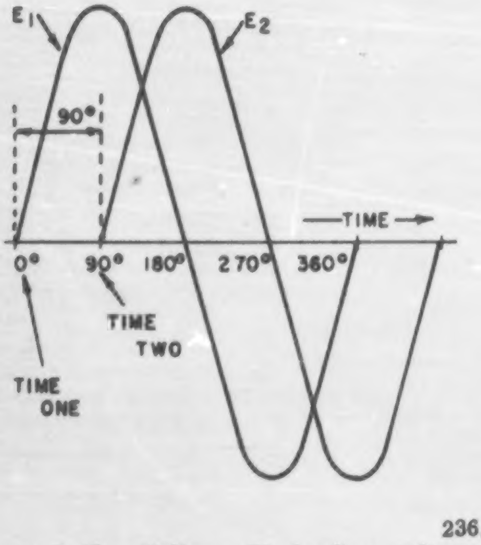
other, so to speak, they are said to be IN-PHASE. To be in phase, the two waves must go through their minimum and maximum points at the same time, in the same direction. This does not mean that they must be of the same amplitude, only that they travel in the same direction at the same time.

Sine Waves Out Of Phase

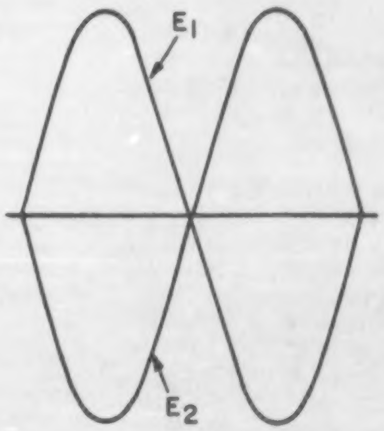
In figure 2-45, we see a voltage wave, E1, starting at 0 degrees, or time zero. As E1 reaches its positive peak, a second voltage wave, E2 starts to rise. Since these two waves do not go through their minimum and maximum points at the same time, a PHASE DIFFERENCE exists between them. The two waves, E1 and E2, are said to be OUT OF PHASE. The amount by which one wave is out of phase with another is measured in degrees. We can see in figure 2-45 that E1 is 90 degrees out of phase with E2.

To further describe the phase relationship between two waves, the terms LEAD and LAG are used. To better understand this, refer again to figure 2-45. Since E2 starts 90 degrees later than E1, E2 is said to LAG E1 by 90 degrees. E1 is said to LEAD E2 by 90 degrees.

Another common phenomenon in electricity is shown in figure 2-46. The two waves, E1 and E2, are 180 degrees OUT OF PHASE. Notice that although the waves pass through their minimum and maximum values at the same time, their values are opposite in polarity and not in the same direction. In such a situation as this, the two waves would cancel each other out if they were of equal amplitude. If one wave was larger than the other (higher in amplitude), then the resultant waveform would be the difference between the two and would have the polarity of the larger wave.



236.181
Figure 2-45.—Voltage E1 leading voltage E2.



236.182
Figure 2-46.—Voltage waves E1 and E2 180-degrees out-of-phase.

Sine Wave Application

What we have done so far in our study of basic a.c. is to show you one of the more simple methods of generating a.c. (with an a.c. generator). However, as we mentioned previously, this is not the only way to produce a.c. In communications, we use various methods, depending upon what we want to do with the a.c. signal. The important thing here is that you understand what an a.c. signal is and some of the more important points in analyzing its representation: The sine wave. However we choose to generate a.c. the basic representation remains the same as well as its rules of amplitude and phase relationships.

Electronic equipment makes extensive use of a.c. in the form of circuit signal voltages. From a tiny a.c. signal generated by a microphone, for example, we can transmit signals around the world. Thus, a.c. plays a role of primary importance in any electronic endeavor. The remaining topics in this chapter deal with two circuit values that are necessary to understand not only from a viewpoint of electricity but also in the later study of antennas. They are inductance and capacitance.

INDUCTANCE

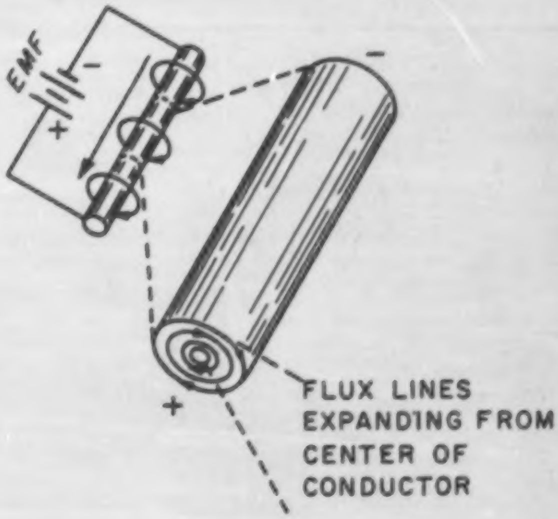
Inductance, as a property of electrical circuits, is a very detailed subject. Our coverage of inductance here will be limited to the more major characteristics of it. It should be pointed out, however, that a study of inductance combines both the principle of magnetism and the physics of electrons. With a basic knowledge of inductance, a person's ability to understand electronic circuits becomes more pronounced and the application of electronic circuits easier to comprehend.

What is Inductance?

INDUCTANCE is defined as the property of an electrical circuit that opposes any change in the current through the circuit. The unit of measurement for inductance is the HENRY, designated "H". The symbol for inductance itself is "L". The henry is a relatively large unit of inductance and is used with relatively large inductors. Usually, the unit encountered will be the millihenry, mH, or the microhenry, uH.

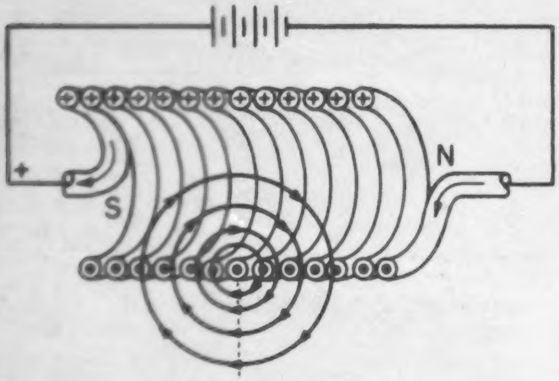
Self-Inductance

Even a straight length of conductor has some inductance. As you know, current in a conductor always produces a magnetic field surrounding and linking it with the conductor. When the current changes, the magnetic field changes, and an emf is induced in the conductor. This emf is called a SELF-INDUCED EMF, because it is induced in the conductor carrying the current. The emf is also called a COUNTER-ELECTROMOTIVE FORCE (CEMF) because it always opposes the applied emf. In figure 2-47, we have shown a simple circuit with a battery and a straight piece of conductor connected to the negative and positive terminals. We have expanded a section of the conductor to more accurately depict cemf. The current-carrying conductor is encircled by flux lines. These flux lines actually start at the center of the conductor and expand outward. In expanding outward, the flux lines cut the conductor, and anytime flux lines cut a conductor, there will be a cemf generated. This cemf builds up at the same rate as the source and in direct opposition to it. It, therefore, OPPOSES the initial build-up in current. It might seem that the cemf would prevent current flow, but it should be pointed out that a cemf will be produced only so long as there is RELATIVE MOTION (flux expanding or collapsing). If a steady rate of current is reached, self induction will cease to exist to any appreciable degree. Therefore, self induction is more pronounced in a.c. circuits than in d.c. circuits.



76.87
Figure 2-47.—"Cemf" in a current-carrying conductor.

The cemf produced due to self induction depends on the amount of flux linkage between one part of the conductor and another part of the same conductor. In other words, a single circular flux line expanding out from the center of the straight wire will cut only the radius of the wire from the center to the surface. Therefore, the cemf produced will be very small. However, if the conductor is wound into a coil, then a single circular flux line expanding out from the center of the conductor in one of these loops will cut many of the other loops. Therefore, the cemf produced will increase because the flux linkage between one part of the conductor and another will be greater. Figure 2-48 shows a coil placed in a circuit containing a simple source. All of the coils in this circuit will now have flux fields built up around them. All of



76.88

Figure 2-48.—"Coiling" a conductor to produce greater induced EMF.

these fields in turn will cut several coils next to the coil emanating the field. As you can see, as we "coil" a wire, the induced emf will become more pronounced. It will also become more pronounced as we decrease the distance between the turns because more turns will be cut by the fields of other coils. The circuit in figure 2-48 is more INDUCTIVE than the circuit shown in figure 2-47.

Now, a natural question: How does inductance oppose any change in current? Without going into a long, involved explanation, the answer is simply this: Taking an a.c. signal as an example, as the voltage builds up on one swing of its two alternations, the cemf produced builds up at the same time, opposing the source voltage. As the a.c. signal starts on its down swing towards zero, the cemf begins to collapse and act as an emf (voltage) by exerting an induced voltage in the same direction that the source acted. This induced voltage tends to keep the current at a higher rate while the source falls to zero and then starts on its [illegible] alternation. Whereupon, the cemf will again oppose it, thereby keeping the current more stable.

Factors Affecting Self Inductance

Many things affect the self inductance of a circuit. An important factor is the degree of linkage between the circuit conductors and its electromagnetic flux. In a straight length of conductor, there is very little flux linkage between one part of the conductor and another. Therefore, its inductance is very small. Conductors become much more inductive when they are wound into coils, as shown in figure 2-49. This is true because of the maximum flux linkage between the conductor turns which lie side by side in the coil.

Inductance is further affected by the manner in which a coil is wound. The coil in figure 2-49(A) is a poor inductor compared to the coil in figure 2-49(B). That is because its turns are widely spaced, thus decreasing the flux linkage between its turns. The more inductive coil shown in figure 2-49(B) has more closely spaced turns and the two layers link each other with a greater number of flux fields during all flux movements. Note that nearly all turns, such as turn (a), are directly adjacent to four other turns (shaded), thus affording increased flux linkage.

The coil shown in figure 2-49(C) is yet more inductive. This was accomplished by winding it in three layers, and providing a highly PERMEABLE core made of IRON. To better understand this, let's define the term PERMEABILITY: The ease with which magnetic lines of force distribute themselves throughout the material. As we all know, iron is very easily magnetized and distributes magnetic lines of force quite easily. The magnetic properties of the iron core increase the total coil flux strength many times that of an air core coil of the same number of turns.

From the foregoing, we can arrive at a few simple conclusions. The primary factors affecting the inductance of a coil are:

(1) The number of turns of conductor,

(2) The ratio of the cross-sectional area of the coil to its length,

(3) The permeability of its core material.

The inductance of a coil is affected by the magnitude of the current when the core is a magnetic material. However, when the core is air, the inductance is independent of the current.

To summarize briefly before going further, the cemf is an INDUCED emf, or voltage. This voltage is induced in conductors of a circuit by means of the magnetic field surrounding any conductor carrying current. Any change in current changes the intensity of this magnetic field, and the resultant emf induced (the counter emf), is self-induced. Thus, the property of a circuit which produces such an emf is called self inductance. Actually, all elements in a circuit, including connecting wires, show some self inductance, but realistically, only those elements designed to make use of this property to advantage are known as inductances, or INDUCTORS.

Magnitude of a Counter EMF (CEMF)

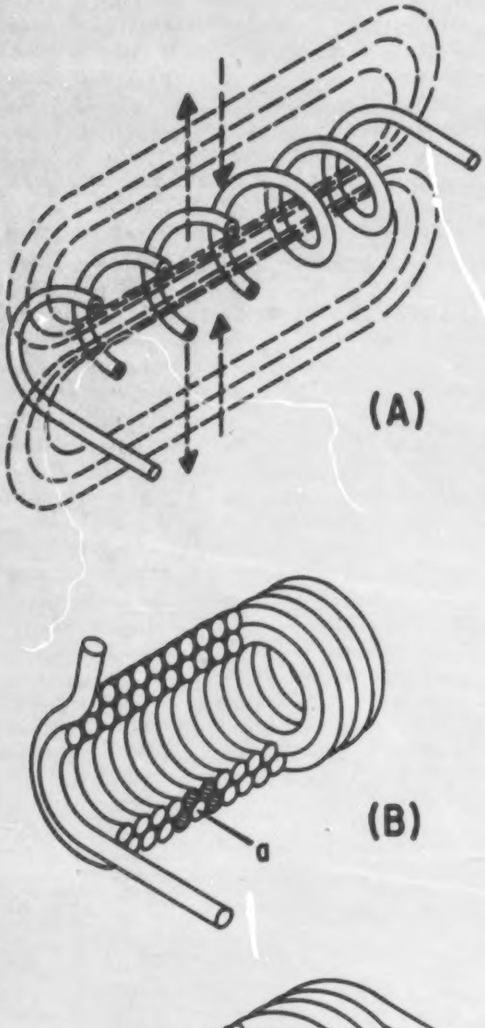
The magnitude of a counter-emf (CEMF) depends upon the same factors that govern any induced emf. Let's restate a law of electromagnetic induction: The EMF induced in any circuit is dependent upon the rate of change of the flux linking the circuit. Since there is no physical movement of the conductor or the lines of force in self inductance, the rate of change of the flux density is dependent upon movement of some kind. Obviously, the magnitude of a self induced emf depends upon the rate of change of the CURRENT in a circuit. Further, it stands to reason that a rapidly changing current induces a greater EMF than a slowly changing current. That is why a self induced emf will not be as great in a d.c. circuit because the current varies very little, therefore, a smaller emf. But for an a.c. circuit, the rate of change of current depends upon the number of Hertz, or the frequency. The counter emf in a.c. circuits then depends upon the frequency.

Mutual Inductance

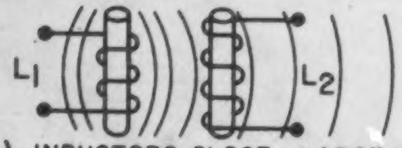
MUTUAL INDUCTANCE occurs whenever two coils are located so that the flux from one coil links with the turns of another coil and produces an emf in that coil. The two coils are said to be "mutually inductive". In figure 2-50, we have shown two coils that are mutually inductive. If the coils are separated a considerable distance, the amount of flux common to both coils is small and the mutual inductance is low. Conversely, if the coils are close together so that nearly all the flux of one coil links the turns of the other, mutual inductance is high. Mutual inductance may be increased by mounting two coils on a common iron core.

As was mentioned previously, the mutual inductance of two adjacent coils is dependent upon the (1) physical dimensions of the two coils, (2) the number of turns in each coil, (3) distance between the two coils, (4) relative positions of the axes of the two coils, and (5) the permeability of the cores.

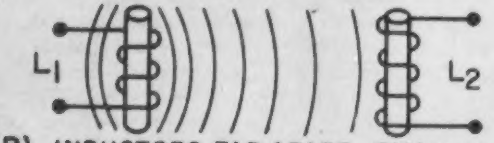
If the two coils are so positioned that all the flux of one coil cuts all the turns of the other, the coils have what is called UNITY COEFFICIENT OF COUPLING. If all of the flux produced by one coil cuts only one-half the turns



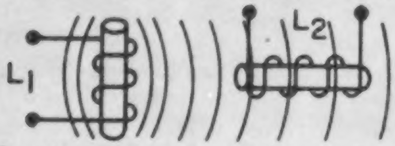
236.185
Figure 2-49.—Coils of various inductances.



(A) INDUCTORS CLOSE--LARGE M



(B) INDUCTORS FAR APART--SMALL M



(C) INDUCTOR AXES PERPENDICULAR--NO M

76.89
Figure 2-50.—Increasing and decreasing mutual inductance.

of the other coil, the coefficient of coupling is 0.5, or 50%. Coefficient of coupling is designated by the letter "k". The coefficient of coupling is equal to the percentage of flux originated by one coil that cuts another coil. It is never equal to unity, but it may approach that value in certain types of coils.

Series and Parallel Inductors

The formulas for determining total inductance in a circuit are simple. Inductance is calculated the same way that resistance is in series or parallel circuits. The following formulas assume that the inductors are well shielded, or located far enough apart to make the effects of mutual inductance almost negligible. For series inductors:

$$L_T = L1 + L2 + L3\ldots\text{etc.}\ldots$$

For parallel inductors:

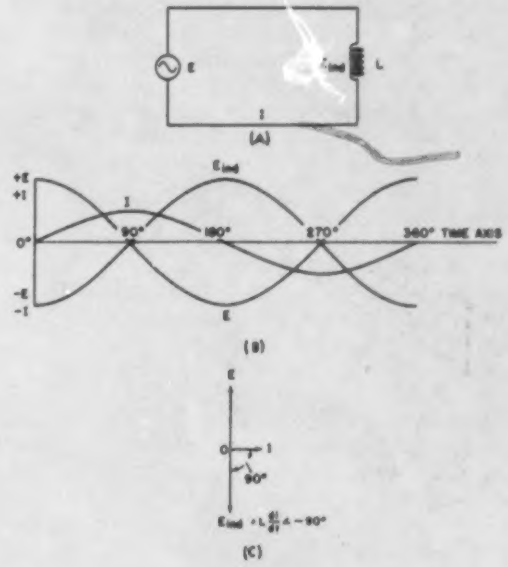
$$\frac{1}{L_T} = \frac{1}{L1} + \frac{1}{L2} + \frac{1}{L3}\ldots\text{etc.}\ldots$$

There is a formula for calculating total inductance whenever the effects of mutual inductance are prevalent. However, at this point, such a discussion would only serve to confuse you. For information relating to that calculation, refer to BASIC ELECTRICITY, NAVEDTRA 10086 series.

INDUCTIVE VOLTAGE AND CURRENT

As stated previously, any change in current, either a rise or a fall, causes a corresponding change in the magnetic flux around a coil. If the current is in the form of a sine wave, the induced voltage will also have the form of a sine wave. The induced voltage always OPPOSES a change in current. Take a look at figure 2-51. When the current is rising in a positive direction from 0 degrees, the induced emf is of opposite polarity to the source emf and opposes the rise in current. Later, when the current is falling towards its zero value at 180 degrees, the induced voltage is of the same polarity as the current and tends to keep the current from falling. Thus, the induced voltage can be seen to LAG THE CURRENT by 90 degrees.

The resistance of the coil is small and the primary opposition to the current flow through



236.195
Figure 2-51.—Inductive voltage and current.

the coil is the induced voltage. The applied voltage, or source voltage, is slightly larger than the induced voltage and is in direct opposition to it. The current lags the applied voltage in an inductive circuit by 90 degrees. The induced voltage is always of opposite polarity to the applied voltage and is called a COUNTER emf or a BACK emf because it always opposes the change of current.

CAPACITANCE

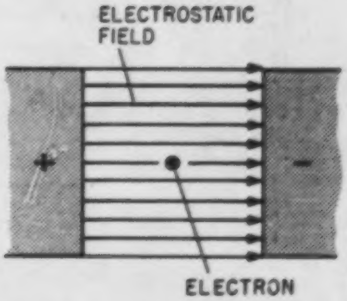
All electrical circuits are composed of either resistance, inductance or capacitance, usually all three. Two conductors separated by a nonconductor exhibit the property of CAPACITANCE, because this combination can store an electric charge. Inductance opposes a change in current. Capacitance is a property of a circuit which opposes a change in voltage. Also, whereas inductance stored energy in an electromagnetic field, capacitance stores energy in an electrostatic field.

Electrostatic Field

When one charged body is brought close to another charged body, there is a force that either causes the charged bodies to attract or repel each other. If these charged bodies have the same sign of charge, they will tend to repel each other. If they have unlike signs, there will be a force of attraction between them. This force of attraction or repulsion is caused by the electrostatic field that surrounds every charged body. If the material is charged positively, it has a lack of electrons. If it is charged negatively, it has an excess of electrons.

Look at figure 2-52. Here we have shown two charged bodies existing in close proximity to each other. One is negatively charged, and one is positively charged. Between these two charged bodies, there is a STATIC FORCE FIELD existing due to natural laws of attraction and repulsion between differently charged bodies. If we could see the lines of force, we would see them emanating from the positive body and going towards the negative body. Remember, these are lines of force, not electrons. An electron will move from negative to the positive material AGAINST the lines of force.

The force between charged bodies is very aptly explained by a common electrical law: The force existing between two charged bodies is directly proportional to the product of the charges and inversely proportional to the square of the distance separating them. In other words, the greater the charge on the charged bodies, the greater will be the force field, and the greater the distance between the charged bodies, the less the force of attraction. An interesting characteristic of electrostatic lines of force is that they have the ability to pass through any known material.



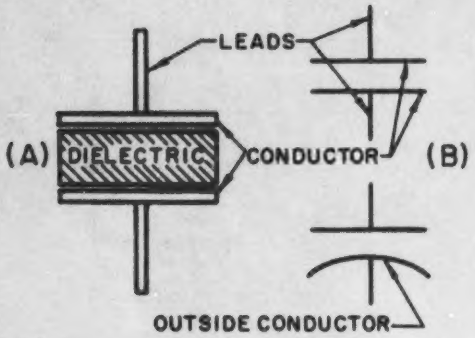
236.198
Figure 2-52.—An electrostatic force field.

The Capacitor

CAPACITANCE is defined as the property of an electrical circuit or electrical device to oppose a change in voltage. Capacitance is also defined as the measure of the ability of two conducting surfaces, separated by some form of nonconductor, to store an electric charge. For the present, we will use air as the insulating material between two conducting surfaces.

The device used in electrical circuits to store a charge by virtue of an electrostatic field is called a CAPACITOR. (The larger the capacitor, the larger the charge that can be stored.)

The simplest type of capacitor consists of two metal plates separated by air. An illustration of a simple capacitor and its schematic symbol is shown in figure 2-53. The conductors that form the capacitor are called PLATES. The material between the plates is called the DIELECTRIC. The two vertical lines in figure 2-53 represent the leads connecting the capacitor to the rest of the circuit. Notice that the schematic symbol (B) and the simple capacitor diagram (A) are similar in appearance. Capacitors, however, may be in many configurations (round, rectangular, square, etc.); but the CROSS-SECTIONAL area of the plates of the capacitor is very large in comparison to the connecting



236.200

Figure 2-53.—Capacitor and its schematic symbol.

conductor leads. What this means primarily is that there is an over-abundance of free electrons available in each plate of the capacitor. If the cross-sectional area and plate material of the capacitor plates are the same, the number of free electrons in each plate must be approximately the same. It is possible, however, to store so large a charge on one plate of a capacitor that the insulating material between the plates will begin to conduct, so there is a limit as to the amount of charge that can be stored in the capacitor.

Figure 2-53(A) shows a capacitor in its simplest form. It consists of two metal plates separated by a thin layer of insulating material, dielectric. When connected to a voltage source, the voltage forces electrons onto one plate, making it negative, and pulls them off the other plate, making it positive. Electrons cannot flow through the dielectric. Since it takes a definite quantity of electrons to "fill up", or CHARGE a capacitor, it is said to have a CAPACITY. This characteristic is referred to as capacitance.

Various materials vary in their ability to support electric flux or to serve as dielectric material for capacitors. The ability of a dielectric material to support electric flux is expressed in a figure known as its DIELECTRIC CONSTANT. Usually a vacuum is used as a reference point for all dielectric materials. The dielectric constant of a material is also defined as a ratio of the capacitance of a capacitor using that particular material as a dielectric to the capacitance of that same capacitor using air as a dielectric. So we actually may define DIELECTRIC CONSTANT in two ways. We may now list the three factors that affect the value of capacitance:

(1) The area of the plates

(2) The distance between the plates

(3) The dielectric constant of the material between the plates

Unit of Capacitance

Capacitance is measured in a unit called the FARAD. The farad can also be defined in terms of charge and voltage. A capacitor has a capacitance of 1 farad if it will store 1 coulomb of charge when connected across a potential of 1 volt. This can be expressed mathematically:

$$C = \frac{Q}{E}$$

where C = Capacitance in Farads

Q = Charge in Coulombs

E = Applied Potential in volts

Do not get the mistaken idea that capacitance depends upon current or voltage. This formula is merely used for finding farads. Capacitance is determined entirely by physical factors already mentioned.

You will probably find, in dealing with electric circuits, that a farad is a very large and cumbersome figure to use. Rarely is capacitance measured in so large a figure. Rather, it is measured usually in microfarads (uf) or micro-microfarads (uuf). To avoid confusion and the use of double prefixes, the term picofarad (pf) is preferred to the term micro-microfarad.

The formula for determining capacitance in a parallel two-plate capacitor is as follows:

$$C = 0.2249 \frac{(kA)}{d}$$

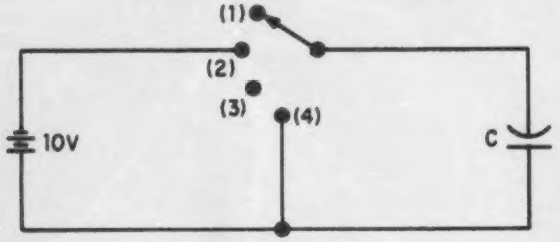
where C is in picofarads, A is the area of one of the plates in square inches, d is the distance between the plates in inches, and k is the dielectric constant of the insulator separating the plates. From this formula it may be seen that the capacitance increases when the plates are increased in area, it decreases if the spacing of the plates is increased, and it increases if the dielectric constant is increased.

Charging a Capacitor

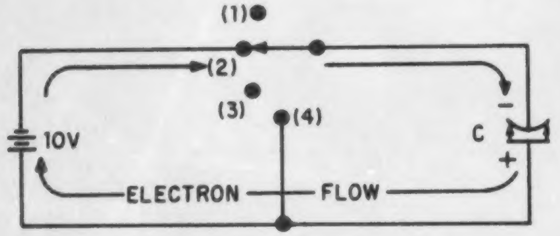
In order to better understand the action of a capacitor, let's examine the "charge" and "discharge" action of a purely capacitive circuit. Take a look at figure 2-54. Here we have shown an uncharged capacitor, (A), and the same capacitor when charging, (B). In figure 2-54 (A), the circuit is shown "open", that is, no current can flow because there is not a complete path. Each plate of the capacitor is a neutral body, and until a difference in potential is felt across the capacitor, no electrostatic field can exist between the plates.

To charge the capacitor, the switch must be in position 2, which places the source voltage across the plates of the capacitor. Although the action is almost instantaneous, we will slow it down and explain what happens.

At the instant the switch is placed in position 2, a displacement of electrons will occur simultaneously in all parts of the circuit. Naturally, this electron displacement is from the negative terminal of the battery toward the positive terminal. In figure 2-55, we show the direction of current flow and the polarities built up in the circuit. As the switch is closed, the positive terminal of the battery extracts an electron from the bottom conductor, and the negative terminal of the battery forces an electron onto the top conductor, or plate, of the capacitor. At the same time, an electron is forced onto the top plate and another is pulled from the bottom plate. Thus, in every part of the circuit, a clockwise displacement of electrons occurs in the manner of a chain reaction.



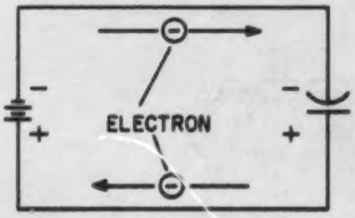
(A) UNCHARGED



(B) CHARGING

236.202

Figure 2-54.—Charging a capacitor.



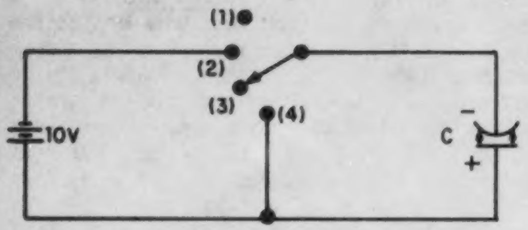
236.203

Figure 2-55.—Polarities during charging of a capacitor.

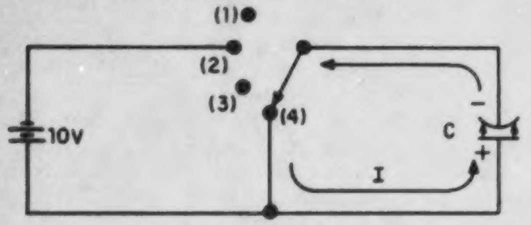
As electrons accumulate on the top plate of the capacitor and others depart from the bottom plate, a difference in potential develops across the capacitor. Each electron forced onto the top plate makes that plate more negative, while each electron removed from the bottom plate makes that plate more positive. Notice that the polarity of the voltage which builds up across the capacitor is such as to OPPOSE the SOURCE, or, in other words, it has a tendency to try to make current flow back the other way, COUNTER-CLOCKWISE. As the capacitor continues to charge, the voltage across the capacitor rises until it is equal in amount to the source voltage. Once the capacitor voltage equals the source voltage, the two voltages balance out, and the current ceases to flow in the circuit.

It should be emphasized at this time that no current flows through the capacitor. The material between the plates of the capacitor must be an INSULATOR.

Look at figure 2-56. We have shown the same circuit as was shown in figure 2-54. The only difference is that we show the 4-position switch in position 3 and in position 4. With the switch shown in position 3, figure 2-56(A), the electrons on the upper plate are now essentially isolated. Thus, the capacitor plate will remain charged indefinitely.



(A) UNCHARGED



(B) DISCHARGING

236.305

Figure 2-56.—Capacitor "storing" a charge (A), then "discharging" (B).

The DIELECTRIC between the plates of a capacitor is not perfect, of course. Usually, a small leakage current will flow through the insulating material to the other plate of the capacitor and eventually will drain the capacitor of its charge. A high quality capacitor may hold its charge up to a month.

At full charge, the electrostatic field between the plates is at a maximum and the energy stored in the dielectric is maximum. If the charged capacitor in figure 2-56(A) is disconnected from the source, the charge will be retained for some period of time. The length of time the charge is retained depends on the amount of leakage current present. Since the electrical energy is stored in the capacitor, a charged capacitor can act as a source.

Discharging a Capacitor

To DISCHARGE a capacitor, the charges on the two plates must be neutralized. This is done by providing a conducting path between the two plates. In figure 2-56(B), we have shown the 4-position switch in position 4. This provides a path for current between the two plates. The excess electrons on the negative plate flow to the positive plate until they equalize and are, therefore, neutralized. It should be noted that a capacitor does not consume power. The energy the capacitor draws from the source is recovered when the capacitor is discharged.

Capacitor Losses

Losses occurring in capacitors may be attributed to either DIELECTRIC LEAKAGE or DIELECTRIC HYSTERESIS. Dielectric Hysteresis may be defined as the change in the orientation of the electron orbits in the dielectric due to rapid reversals of polarity and line voltage. The amount of loss depends upon the type of dielectric used.

Dielectric leakage occurs in a capacitor as the result of current leaking through the dielectric. Normally, of course, it is assumed that the dielectric will effectively prevent the flow of current through the capacitor. However, as mentioned previously, a small amount of current does flow between the plates of a capacitor. This current is so small that it is considered insignificant as a loss. If the leakage through the dielectric is abnormally high, however, there will be a rapid loss of charge and an overheating of the capacitor.

The POWER FACTOR of a capacitor is determined by dielectric losses. If the losses are negligible, the capacitor is considered to be near perfect and has a power factor of zero. Therefore, the power factor of a capacitor is a measurement of its efficiency.

Voltage Rating of Capacitors

In selecting or substituting a capacitor for use in a particular circuit, consideration must be given to (1) the value of capacitance desired and (2) the amount of voltage to which the capacitor is to be subjected. If the voltage applied across the plates is too great, the dielectric will break down and arcing will occur between the plates. The capacitor is then short-circuited and the possible flow of direct current through it can cause damage to other parts of the equipment. Capacitors have a voltage rating that should not be exceeded.

The "working voltage" of the capacitor is the maximum voltage that can be steadily applied without danger of "arc-over". The working voltage depends on (1) the type of material used as the dielectric and (2) the thickness of the dielectric.

The voltage rating of the capacitor is a factor in determining the capacitance because capacitance decreases as the thickness of the dielectric increases. A high voltage capacitor that has a thick dielectric must have a larger plate area in order to have the same capacitance as a similar low voltage capacitor having a thin dielectric. The voltage rating also depends on the frequency because the losses and the resultant heating effect increase as the frequency increases.

A capacitor that may be safely charged to 500 volts d.c. cannot be safely subjected to alternating or pulsating direct voltages whose effective values are 500 volts. An alternating voltage of 500 volts (rms) has a peak voltage of 707 volts, and a capacitor to which it is to be applied should have a working voltage of at least 750 volts. The capacitor should be selected so that its working voltage is at least 50 per cent greater than the highest voltage to be applied to it.

Calculating Capacitance

Calculating capacitance is really quite simple if you can remember one basic rule-of-thumb: Calculate capacitance exactly opposite the way you would calculate resistance. In other words, for capacitors in SERIES, the formula would be:

$$\frac{1}{C_T} = \frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3} \ldots \text{etc.} \ldots$$

We use the RECIPROCAL method, just as we did for parallel resistors. We can also use the product over the sum method when only two capacitors are involved in series:

Where $$C_T = \frac{C1 \times C2}{C1 + C2}$$

just as we did for resistors in parallel.

For calculating capacitors in parallel, the same rule of thumb applies: opposite the way you would calculate resistance. As an equation, it would be: $C_T = C1 + C2 + C3$. . .etc. just as we did for resistors in series.

INDUCTIVE AND CAPACITIVE REACTANCE

Inductive Reactance

We mentioned previously that the opposition that an inductance offers to a changing current was called induced voltage or cemf and has been measured in volts. This is true insofar as a coil can build up a cemf that will oppose the source in polarity, then aid the circuit by aiding the current flow in it. However, opposition to current flow is normally measured in ohms, not volts. The ohm, of course, is a measure of resistance. Since a coil reacts to a current change by generating a cemf, a coil is said to be REACTIVE. The opposition of a coil is, therefore, called REACTANCE (X), and is measured in ohms. Since more than one kind of reactance exists, the subscript L is added to denote INDUCTIVE REACTANCE, (X_L). Thus, the opposition offered by a coil to alternating current is inductive reactance or X_L.

At this point, we can now state a formula that allows us to solve for inductive reactance. It is important that you understand the relationship between inductive reactance and frequency. The formula is as follows:

$$X_L = 2\pi fL$$

where: X_L = Inductive Reactance in Ohms
2π = 6.28 (Number of RADIANS in One Cycle)
f = Frequency in Hertz
L = Inductance in Henrys

It has already been said that the cemf of a coil depends on the coil's inductance and the rate of flux change around the coil. The rate of flux change, of course, depends upon the frequency, or number of alternating cycles per second (Hertz). Therefore, we can change the reactance of a coil by changing its inductance or by changing the input frequency to the coil. As we increase the frequency, the rate of flux change also changes because of the inherent characteristic of a coil to build up magnetic flux fields around the turns comprising the coil. The formula, of course, tells us that if we vary either inductance or the frequency, then we change inductive reactance. Since most inductors are manufactured at fixed values, the only variable factor affecting the inductive reactance of a coil, normally, is frequency. As we increase the frequency applied to a coil, we increase the reactance of the coil to current flow, or, its resistance to the applied frequency or current. This reactance, or resistance, is measured in ohms and exhibits the same properties that a resistor of that value would exhibit to current flow if placed in the circuit. Remember, reactance is a resistance, not an inductance.

Capacitive Reactance

The definition of capacitance was stated as the ability to oppose a change in applied voltage. It has been stated that a capacitor charges to the value of the source. At the time that the charge of a capacitor equals the applied voltage, no more current flows. Since a capacitor REACTS to a voltage by producing a cemf, a capacitor is said to be REACTIVE. The opposition of a capacitor, is therefore, called REACTANCE (X) and is measured in ohms. In order to distinguish capacitive reactance from inductive reactance, the subscript "C" is added to the symbol X. The opposition offered by a capacitor to alternating current is termed CAPACITIVE REACTANCE and designated by XC.

It is not necessary that you understand all of the reasons for the formula, but it is important that you understand its relationship to applied frequency. The formula is as follows:

$$XC = \frac{1}{2\pi f C}$$

where:

XC = Capacitive Reactance in Ohms
2π = A Constant
f = Frequency in Hertz
C = Capacitance in Farads

As you can see, the two values that will change the reactance of a capacitor are the frequency and the capacitance. If a capacitor has a fixed value, then the only variable will be frequency. Often, however, capacitors are variable and the reactance of a capacitor may vary widely depending upon the applied frequency to a circuit and the varied setting of the capacitor. The entire product of 2πfC is divided into the number "1", as shown by our formula. The reason for that, in simple terms, is that the reactance of a capacitor is an inverse function of the capacitance of a capacitor. The important thing here is to realize that the reactance varies INVERSELY with the applied frequency and capacitance. In other words, if we increase either capacitance or frequency, we will find that capacitive reactance decreases, and vice-versa. This is exactly opposite to inductive reactance where it varied directly. So, as you can see, capacitive and inductive reactance are exactly opposite values for the same applied frequency.

Impedance

Impedance is the TOTAL OPPOSITION to the flow of alternating current in a circuit that contains resistance and reactance. In a purely inductive circuit, the only resistance to a.c. is the reactance; therefore, the reactance would be the impedance, or total opposition to current flow. In a purely capacitive circuit, the only resistance to a.c. is the reactance. Therefore, reactance would be the impedance. However, in a circuit comprised of resistors, capacitors, and inductors (which is nearly always the case), impedance would be the combined values of resistance, capacitive reactance, and inductive reactance. They are all measured in ohms and must be cumulatively figured to determine their combined effects in a circuit, which would be equivalent to the impedance of the circuit.

It should be pointed out that it is the combined effect of all of these properties that make up impedance. By that we mean that you cannot add the reactances to the resistance and find impedance. Impedance must be plotted on a graph and solved geometrically. This is because the reactances are inversely proportional to each other as was mentioned earlier. We may only find their CUMULATIVE, or NET effect in a circuit. This value is impedance.

Appendix III contains a list of the formulas discussed in this chapter.

CHAPTER 3

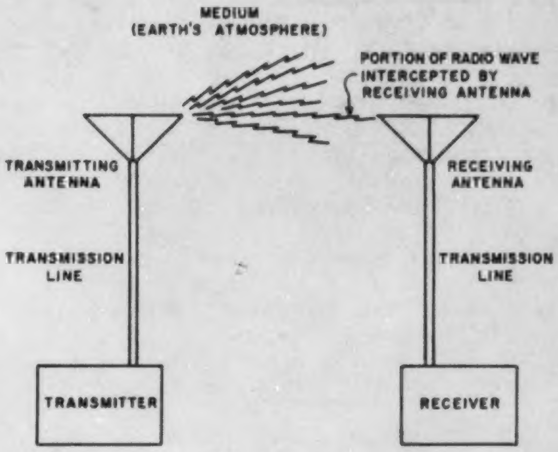
BASIC TRANSMITTER THEORY

In today's modern Navy, communications is the nerve center. Without it, all of our sophisticated weaponry would be useless and coordinated naval operations would be impossible. Naturally, this calls for communications and equipment to be reliable, secure, and rapid. Our equipments today are more complex than ever and are becoming more so. It stands to reason that, with the advent of more complex communications equipments, communications itself will become more complex and capabilities will increase.

Transmitting and receiving communication signals is the job of the RM. Receiving signals, of course, involves receiving equipment, whereas the transmission of signals involves transmitters. The thousands of pieces of communications ancillary and terminal equipment are worthless if our basic transmitters and receivers aren't working. It is, therefore, very important for you to understand basic transmitter and receiver theory. In this chapter, we will discuss the various types of communications transmitters, their functional block diagrams, and associated circuitry. Your knowledge of communications equipment not only increases your professional proficiency, it enchances your ship's capability to successfully operate with other units that may be in company as well as naval shore-communication centers.

THE BASIC COMMUNICATION SYSTEM

In figure 3-1, we show a simple [illegible] communication network. In it we can identify each basic element needed to establish radio communications; a TRANSMITTER, a TRANSMISSION LINE, and a TRANSMITTING ANTENNA; a MEDIUM (earth's atmosphere); and a RECEIVER, a RECEIVING TRANSMISSION LINE, and a RECEIVING ANTENNA. If we took away any one of these elements, we could not effectively communicate.



31.6

Figure 3-1.—Simple Radio Communication Network.

Communications transmitters operate on frequencies ranging from 3000 hertz to several gigahertz (GHz). Most shipboard transmitters operate in the medium frequency and high frequency (MF/HF) bands of frequencies, as do the receivers. The HF band lends itself well to long-range communications which would account for its extensive usage.

In the very low frequency (VLF) band (3 - 30 kilohertz (kHz), signals can be transmitted over long distances and through magnetic storms that might blank out higher bands. This band of frequencies is used primarily for the transmission of time standards, radio navigation, and fleet broadcasts.

In the low frequency (LF) band (30-300 kHz), signals are used for long range direction finding, medium and long range communications, and aeronautical radio navigation.

In the medium frequency (MF) band (300-3000 kHz), relatively long distances can be covered. The international distress frequency, 500 kHz, is in this band. Commercial communications facilities also use this band extensively.

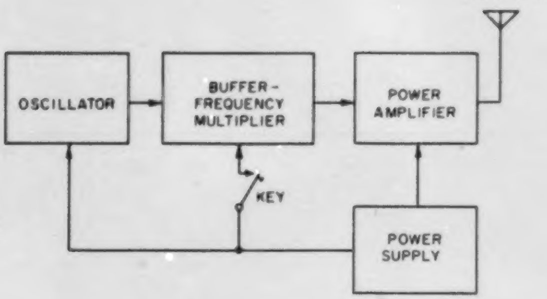
In the high frequency (HF) band (3 - 30 megahertz (MHz)), mobile and maritime communications units are primary users.

The very high frequency (VHF) band (30-300 MHz) is used for aeronautical radio navigation and communications, radar, and amateur radio.

The ultra high frequency (UHF) band (300 MHz - 3 GHz) is used for short-range communications.

This is only a partial listing of the usage of each band. To find a complete list of frequencies and usages, consult NTP 6 and ACP 190.

The overall purpose of a radio transmitter is to produce radiofrequency (RF) energy and, with its amplifiers, coupler, and antenna, to radiate a useful signal. The basic construction of a "typical transmitter" is shown in figure 3-2. There are many variations, of course, due to the many communication requirements, but every transmitter has the basic components shown in figure 3-2. We will discuss each transmitter component in detail as we progress through this chapter.



20.201

Figure 3-2.—Stages of a typical transmitter.

TYPES OF TRANSMITTERS

There are many types of transmitters in use in today's Navy. Each type has its own method of producing the kind of signal for which it was designed. Most transmitters are basically simple in what they do in that their basic function is to TRANSMIT. However, the method by which they accomplish their particular MODE or MODES (methods) of operation may sometimes be quite complex because of the complex circuitry contained in the equipment. In this chapter, we will not deal with the extreme complexities; rather, we will deal with the major circuits, and discuss their functions in the various types of transmitters that we will be talking about.

CONTINUOUS-WAVE (CW) TRANSMITTER

Continuous wave (CW) is used principally for radio-telegraphy—that is, for the transmission of short or long pulses of RF energy to form the dots and dashes (dits and dahs) of the Morse code characters. CW was the first type of radio communications used and is essentially a long-range mode. Although the Navy no longer uses CW as a primary means of communication, it is still an alternate mode in most communication situations. Some of the advantages of CW transmission are narrow bandwidth, high degree of intelligibility under severe noise conditions, and long-range capability.

The essential elements of a CW transmitter are (1) a generator of RF oscillations, (2) a means of amplifying these oscillations, (3) a method of turning the RF output on and off (keying), and (4) an antenna to radiate the keyed output of the transmitter. A block diagram of a CW transmitter is shown in figure 3-2.

As the block diagram shows, we satisfy the four requirements of a CW transmitter. The OSCILLATOR is used to generate the RF CARRIER at the assigned or selected frequency. The BUFFER AMPLIFIER isolates the oscillator from the stages electrically "downstream" of it, thus preventing load oscillations and variations from affecting the operation of the oscillator. The BUFFER also provides amplification of the signal coming from the oscillator. The POWER AMPLIFIER provides further amplification of the generated signal. The ANTENNA, of course, is used to radiate the RF carrier, and the POWER SUPPLY provides all operating voltages for the components within the individual stages.

One or more stages of amplification may be used between the buffer and the antenna. The stage which is connected to the antenna is usually called the final Power Amplifier (PA), as shown in figure 3-2. Any other stages of amplification are known as Intermediate Power Amplifiers (IPA). In figure 3-3, we have shown a typical transmitter from the oscillator to the power amplifier. The only difference is that we have two IPAs between the buffer and the PA.

The KEY is used to turn the buffer on and off. When the key is closed, the RF carrier passes through the buffer stage, and when the key is open, the RF carrier is prevented from passing through. This key, of course, corresponds to the hand-key known primarily to Radiomen. When the key is depressed to send a dit or a dah, the current flows, and the path is closed to the PA. When it is not depressed, no current will flow, and no dit or dah will be sent.

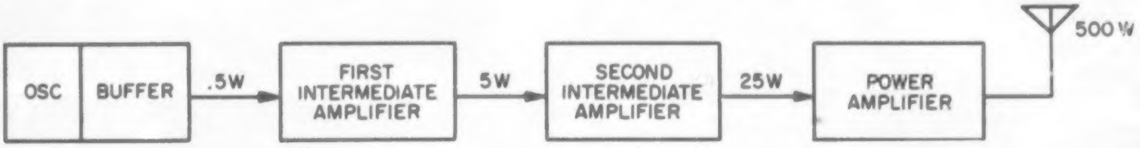
Oscillator

The question that should arise at this time is, "What is an oscillator?" This question can best be answered by defining what an oscillator does. The primary function of an oscillator is to generate a given WAVEFORM at a constant amplitude, at a specific predetermined or preselected frequency, and maintain this waveform within certain limits. Most RF oscillators are capable of generating all of the frequencies required by their associated equipment. In other words, the oscillator of an MF/HF transmitter can generate all of the frequencies required in the MF/HF band. Therefore, an oscillator is a non-rotating device for producing a.c., the frequency being determined by the characteristics of the device. By "characteristics of the device", we mean that some oscillators operate at only one frequency while others may generate millions of different frequencies.

The fact that a circuit is capable of oscillating does not make it a useful oscillator. A circuit must be able to generate sustained oscillations in a desired and controllable manner. Without the electronic oscillator, very few advanced electronic circuit applications would be possible. You will find that oscillators are used in almost every receiver as well as in transmitters. Although the job in each is different in nature, the oscillator still performs the same basic function: It generates an a.c. signal at a constant amplitude. The frequency of the a.c. may vary depending upon the frequency selection desired when operating a transmitter, but an a.c. signal at a constant amplitude is a must.

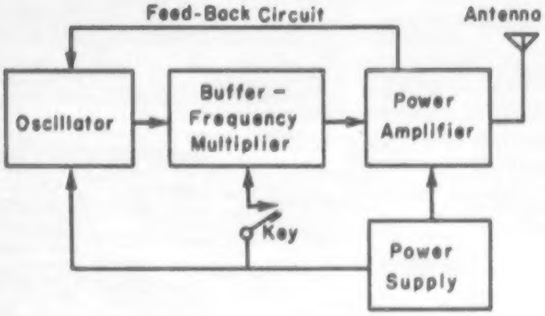
In figure 3-4, we have shown a typical transmitter block diagram. The only difference is the addition of a "feedback circuit." In a basic oscillator, the two main sections are the frequency-determining network (the circuit that generates the a.c. waveform) and a feedback network to help the oscillator sustain oscillations (continue generating the a.c. signal for which it was designed). This feed-back signal, which has a low amplitude, normally emanates from one of the output stages of the transmitter and is fed back to the oscillator to provide REGENERATIVE or POSITIVE feedback. Without going into the complexities of this, all we are doing is aiding the oscillator in its primary job of supplying the transmitter with the selected frequency.

Nearly every piece of equipment that uses an oscillator has two main requirements of the oscillator: AMPLITUDE STABILITY and FREQUENCY STABILITY. The rigidity with which



76.15

Figure 3-3.—Intermediate Power Amplifiers (IPA).



76.89
Figure 3-4.—"Feed-back" path to the oscillator.

these requirements must be met depends on the accuracy demanded of the equipment it serves.

Amplitude stability refers to the ability of the oscillator to maintain a constant amplitude output waveform. The less the deviation from a predetermined amplitude, the better is the amplitude stability.

Frequency stability refers to the ability of the oscillator to maintain the desired operating frequency. The less the oscillator drifts from the operating frequency, the better is the frequency stability.

The topic of oscillators is a very involved one. Much can be said about oscillators and the many types. However, for purposes of our discussion, it is only necessary that you know what a transmitter oscillator does: Generate a.c. at the desired frequency. For more detailed information concerning oscillators, consult the current edition of Basic Electronics, NAVEDTRA 10087, Vol I.

Buffer

The BUFFER AMPLIFIER, or first IPA, is a voltage amplifier that increases the amplitude of the oscillator signal to a level that will drive the power amplifier (PA). The signal delivered by the buffer varies with the type of transmitter, but it may be hundreds or thousands of volts.

The buffer serves two other purposes, one of which is to isolate the oscillator from the amplifier stages. Without the buffer, changes in the amplifier due to keying or variations in the source voltage would vary the load on the oscillator and cause it to change frequency. It may also be used as a frequency multiplier to increase the oscillator frequency to the desired operating frequency. Figure 3-4 shows the relative position of the buffer with relation to the oscillator and PA.

Power-Amplifier (PA)

A transmitter is a device for converting intelligence, such as voice or code, into electrical impulses for transmission through space from a radiating antenna. The simplest transmitter consists of an oscillator which generates a high frequency radio signal and an antenna system to propagate the energy. There are two drawbacks to connecting the oscillator directly to the antenna. The first is that the power output would be limited because there are no stages of RF amplification between the oscillator and the antenna to build up the strength of the RF signal. Power output is important because it determines the distance over which the transmitted signal can be picked up by a receiver. The other consideration is frequency stability. The load impedance of the oscillator, in this case the antenna, that is reflected back into the frequency circuit has a great effect upon the frequency stability of the oscillator. The reflected impedance may contain both resistive and reactive components. The reactive components may alter the frequency of the oscillator. A drift in the frequency of the transmitted signal would mean that a portion of a message could be lost at the receiving end.

To overcome the limitations of connecting an oscillator directly to the transmitting antenna, one or more stages of amplification are connected between the oscillator and the antenna. This is shown in block form in figure 3-5. It is in the FINAL PA that the generated signal is amplified to its largest value. The final PA usually has a greater gain with reference to its input, than any intermediate amplifier.

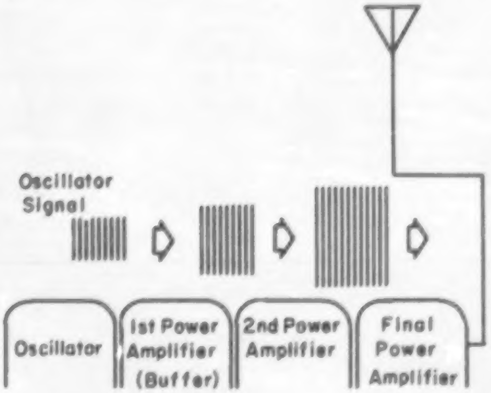
Power Supply

Power supplies do exactly as their name would indicate: They supply power to the equipment for

70

which they were designed. A transmitter, as well as any other piece of electronic equipment, is made up of many different circuits with many components comprising each circuit. The power supply provides all of the operating voltages, both a.c. and d.c., to the individual components and various circuits.

Most power supplies must provide both a.c. and d.c. at the same time to satisfy all of the requirements of the individual circuits. The output of a power supply is usually a.c. If d.c. is needed from the supply, the a.c. signal being supplied must be converted to d.c. This is usually done by a process called RECTIFICATION. When an a.c. signal is rectified, it means that a cycle of a.c. is changed to PULSATING d.c., or one-half of a cycle of a.c. To further reduce a rectified a.c. signal to a nearly constant-amplitude d.c., the signal must be FILTERED. Figure 3-6 shows the a.c. output of a power supply going to the various circuits needing a.c., and shows the a.c. being rectified to pulsating d.c. and then filtered to an almost constant d.c.



76.90

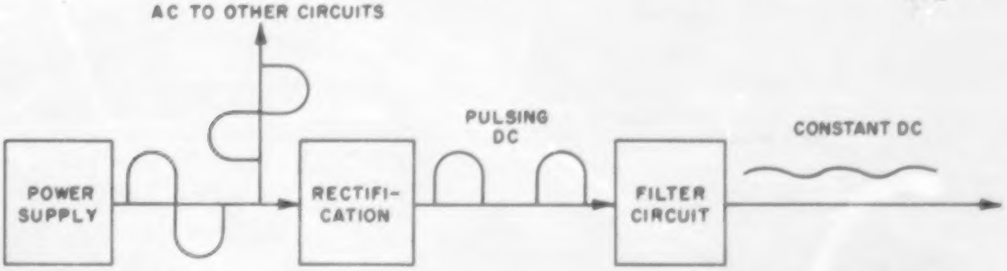
Figure 3-5.—Stages between the oscillator and antenna.

AMPLITUDE-MODULATED (AM) TRANSMITTER

Modulation

As we have already discussed, whenever we activate a transmitter, the oscillator generates a signal, or waveform, that is constant in frequency and amplitude. This signal, however, does not convey any intelligence by itself. This output is called the CARRIER WAVE, or simply the CARRIER, and any information to be transmitted is added to it. This process of adding, or superimposing, information on the carrier is called MODULATION.

Why do we modulate? Why not just transmit the intelligence as it is, say, our voices on a voice net? The reason is really quite simple. As you will see later, the longer the wavelength of a transmitted signal, the larger the antenna must be. Conversely, the shorter the wavelength of a transmitted signal, the shorter the antenna need be. Most speech frequencies fall almost entirely below 3 kHz and to construct corresponding antennas ashore would require prohibitively large amounts of land, be expensive to construct, and consume enormous amounts of power. To install such antennas on ships would be practically impossible. Therefore,



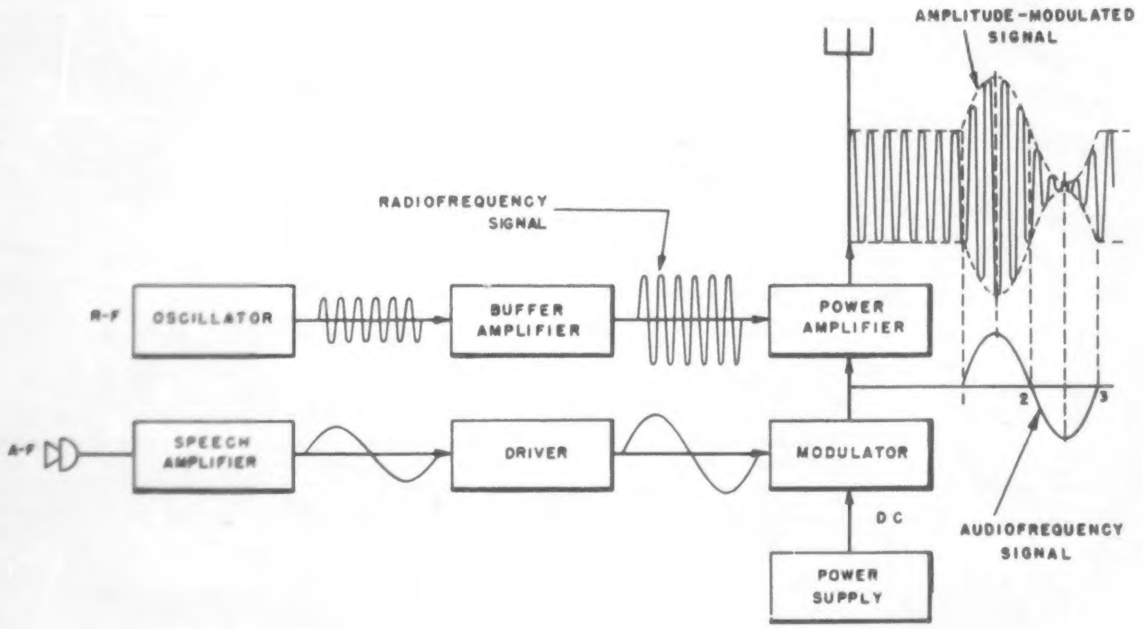
76.91

Figure 3-6.—AC signal being RECTIFIED and FILTERED.

the solution to the problem of long wavelengths is to translate, or transpose, the voice information up into a higher part of the frequency spectrum where wavelengths are shorter and more compatible with practical antenna sizes. Such frequency translation is accomplished by the process of modulation. The topic of wavelengths and antenna sizes is covered thoroughly in Antennas, Chapter 5, of this publication.

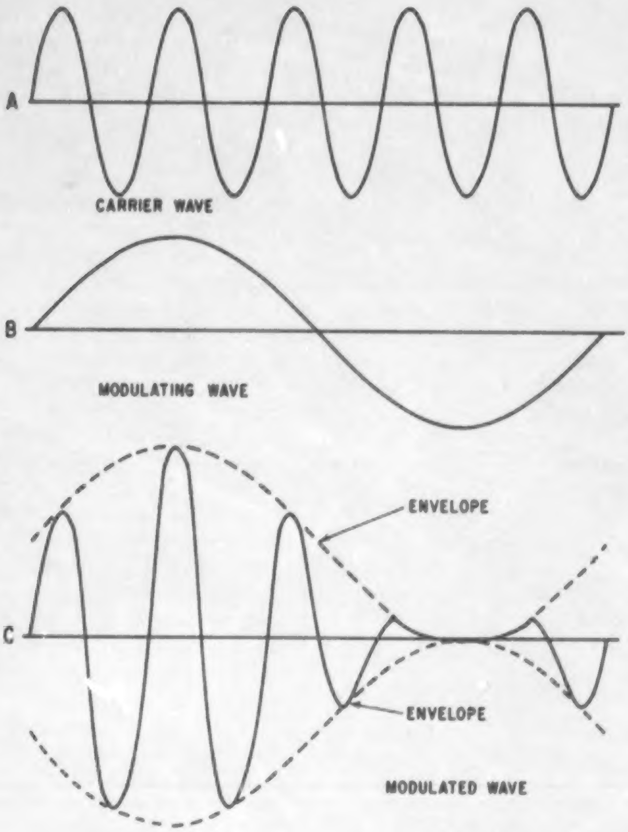
Whenever we modulate, we combine the signal that we want to transmit with the carrier. In the AM transmitter, we are modulating the carrier wave with the voice. Figure 3-7 shows a typical AM transmitter and its basic block diagram. The idea here is to cause the output signal from the PA to vary in amplitude according to the current or voltage variations of the modulating signal (the voice). As we mentioned above, the frequency of the voice is much lower than the frequency of the carrier wave generated by the oscillator. Our voices create a.c. waveforms whenever we speak and these a.c. waveforms vary at the rate of our voice variations. Needless to say, the a.c. waveforms created by our voices are quite irregular with many high and many low points to be seen if we were to look at our voices on the screen of an oscilloscope (a device used to produce a visual representation of waveforms on a screen). Repeating, the desired result when amplitude modulating is to vary the output signal of the transmitter at the same rate that the modulation is varying. When an information wave, normally referred to as a modulating wave, is impressed on a carrier, the result is that their voltages are combined in such a manner as to produce a COMPLEX WAVE (a wave composed of two or more parts). This complex wave is the modulated wave and is the waveform that is transmitted through space. In figure 3-8, we have shown the carrier wave (A), the modulating wave (B), and the complex-wave (C). The complex or modulated wave is contained inside the ENVELOPE. This envelope is the total bandwidth and amplitude of the transmitted complex wave.

Let's refer back to figure 3-7 and define the various parts of the AM transmitter. As can be seen, the oscillator, buffer, and power amplifier



13.53

Figure 3-7.—Typical Radiotelephone Transmitter (AM).



76.92

Figure 3-8.—Carrier wave, modulating wave and amplitude modulated wave.

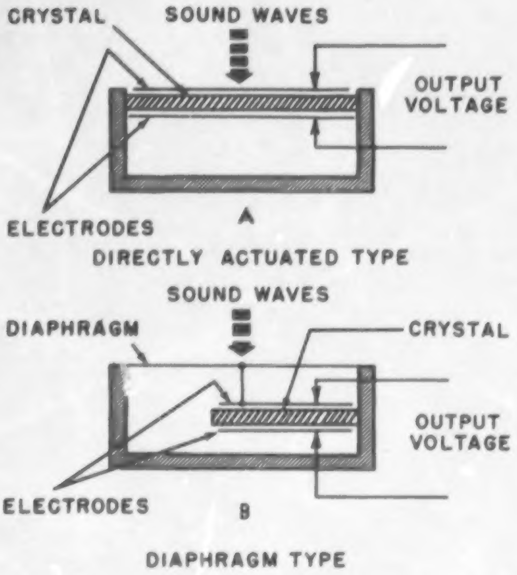
perform the same function as in the typical transmitter discussed previously. However, we have added a few necessary circuits that will accomplish amplitude modulation for us: A microphone, speech amplifier, driver, and modulator.

The microphone takes the sound energy and converts it into electrical energy. The diaphragm of the microphone moves in and out in accordance with the compression generated by sound waves as you speak into it. The diaphragm is connected to a device that causes current to flow in proportion to the instantaneous pressure delivered to it. For good quality sound reproduction, the signal from the microphone must correspond in frequency content to the original sound waves, or your voice. Figure 3-9 shows the basic make-up of a microphone, in this case a crystal mike.

The speech amplifier takes the signal coming from the microphone and builds it up to several volts at the input of the driver stage. The signal coming from the microphone is usually considerably less than 1 volt. The signal is comprised of your voice waves being reproduced through the microphone.

The driver stage is made up of power amplifiers that convert the signal into a relatively large voltage. It does just as its name implies, it "drives" the signal to a very large voltage to build the signal to a level to modulate the carrier.

The modulator is the stage that is connected directly to the power amplifier. It takes the driven signal from the driver and feeds it to the power amplifier in such a way as to alternately add to and subtract from the plate voltage of the power amplifier. This adding and



20.219
Figure 3-9.—Crystal Microphone.

subtracting is done at the same rate of the audio modulation and forms the modulated wave shown at the output of the antenna.

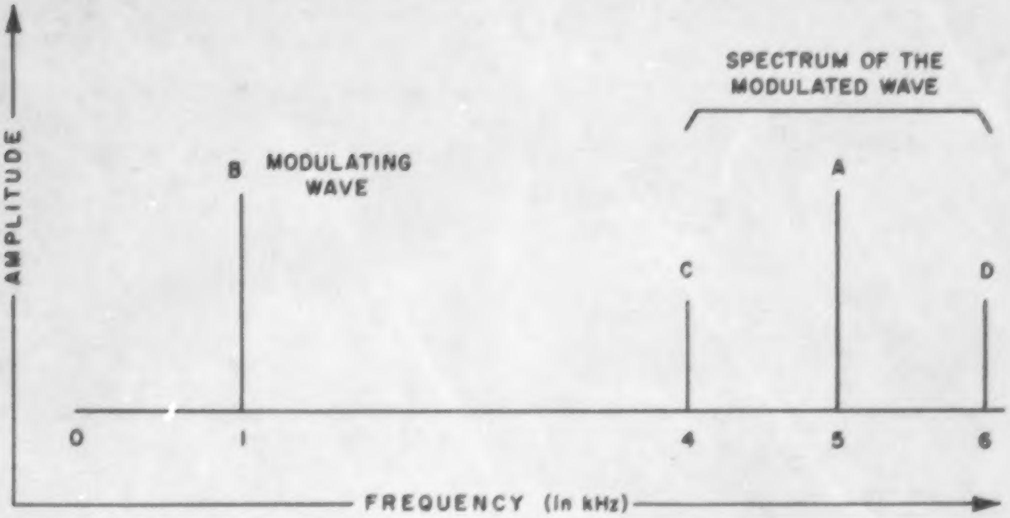
The result of modulation is that the amplitude of the RF field at the antenna is increased gradually during the time the audio frequency (af) output is increasing the RF power. Amplitude is decreased gradually during the time the af output is decreasing the RF power. In other words, during the positive alternation of the audio signal (between point 1 and point 2 in figure 3-7), the amplitude of the RF output wave is increased. During the negative alternation (between point 2 and 3), the amplitude is decreased. Amplitude modulation consists of varying the amplitude of the RF antenna current (and RF output wave) gradually over the relatively long af cycle. Thus, the RF field strength is alternately increased and decreased in accordance with the af signal and at the af rate.

AM Spectrum And Bandwidth

As was previously explained, whenever the intelligence to be transmitted is superimposed on the carrier in the form of changes in the amplitude of the RF energy, the resulting modulation is called amplitude modulation or AM. However, we do other things to the transmitted wave besides simply to modulate it.

When an RF carrier is modulated by a single audio modulating frequency, two additional frequencies are produced. One of these frequencies is the sum of the RF carrier and the audio frequency. The other is the difference between the RF carrier and the audio frequency. The sum frequencies are known as the UPPER SIDEBAND and the difference frequencies are known as the LOWER SIDEBAND. These new frequencies are called SIDE FREQUENCIES because they appear beside the carrier when the wave is displayed on a spectrum analyzer (a type of electronic device that displays waveforms along a horizontal axis, from left to right in ascending order of frequency.) Each frequency or waveform shown by a spectrum analyzer is represented by a vertical line; its amplitude is represented by the height of the line. The spectrum of an AM wave is shown in figure 3-10. The carrier frequency (A) is 5 kHz and the modulating frequency (B) is 1 kHz. The lower side frequency (C) is 5 kHz minus 1 kHz (4 kHz), and the upper side frequency (D) is 5 kHz plus 1 kHz (6 kHz). This is the type of display that would be seen on a spectrum analyzer.

Note that the modulating frequency in fig. 3-10 is not part of the spectrum of the modulated wave. It is, however, represented in that spectrum twice: Once by the lower sideband, and once by the upper sideband. Notice also that the amplitude of each side frequency is only one-half that of the modulating wave. In AM, the power contained in a modulating wave is redistributed equally between the sidebands produced by it. This redistributed energy adds to the carrier power to increase the total amount of energy radiated. This process of combining two frequencies in such a way as to produce sum and difference frequencies is called MIXING or HETERODYNE action. The space which a carrier and its associated sidebands occupy in the frequency spectrum is called the BANDWIDTH. If the carrier and the modulating signal are constant in amplitude, the sum and difference frequencies will also be constant in amplitude. However, when the carrier and the sidebands are combined and could be viewed simultaneously with an oscilloscope, the resultant waveform



76.93

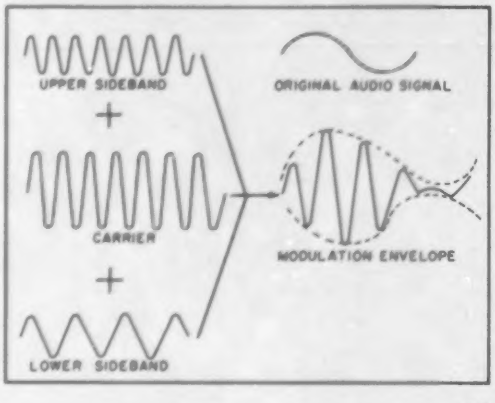
Figure 3-10.—Carrier, Modulating Wave, and side frequencies.

would appear as shown in figure 3-11. This resultant wave is called the MODULATION ENVELOPE.

Spectrum For Multiple-Modulation

Multiple-modulation simply means modulating a carrier with more than one frequency. Instead of having one upper sideband frequency and one lower sideband frequency, we have more than one of each. More simply stated, we have a band of upper and a band of lower sidebands. Each frequency in the band produces its own pair of side frequencies, resulting in a much more complex spectrum. This is shown in figure 3-12, as seen on a spectrum analyzer. Notice that the bandwidth is equal to twice the modulating frequency (BW = 2 x Highest Mod Freq). This is a constant in all modulated waves.

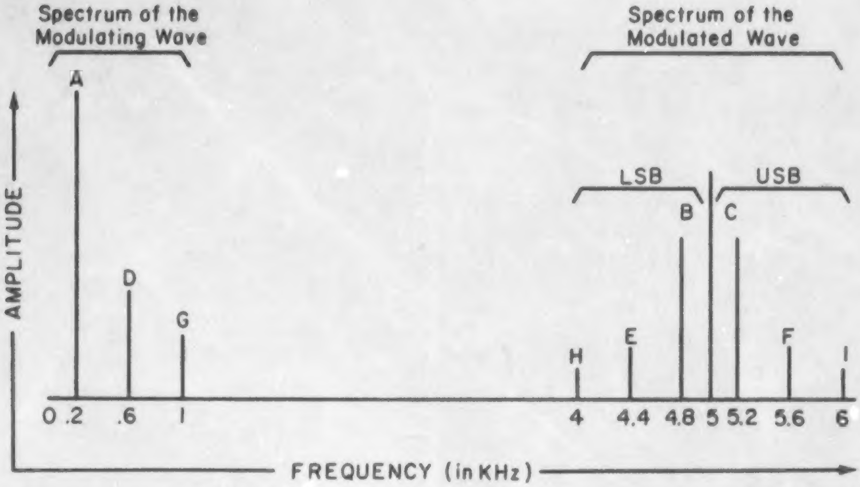
The lowest frequency of the modulated wave in figure 3-12 is .2 kHz (A). It produces a lower side frequency (B) of 4.8 kHz and an upper side frequency (C) of 5.2 kHz. The next highest modulating frequency (D) is .6 kHz. It results in a lower side frequency (E) of 4.4 kHz and an upper side frequency (F) of 5.6 kHz. The highest modulating frequency (G) produces side frequencies (H and I) of 4 and 6 kHz respectively.



76.94

Figure 3-11.—Formation of the modulation envelope.

Those side frequencies in figure 3-12 that are higher in frequency than the carrier are referred to collectively as the upper sideband. It can be seen that the upper sideband is an exact replica of the modulating wave. The order and spacing of frequencies are the same as in the modulating wave, and their relative amplitudes are the same (even though the modulating



76.95

Figure 3-12.—Modulating wave on left, and the resultant modulated wave on right.

wave gave only one-half of its amplitude to the upper sideband.) It is appropriate then to say that the information contained in the modulating wave has merely been translated, or transposed, to a higher part of the frequency spectrum.

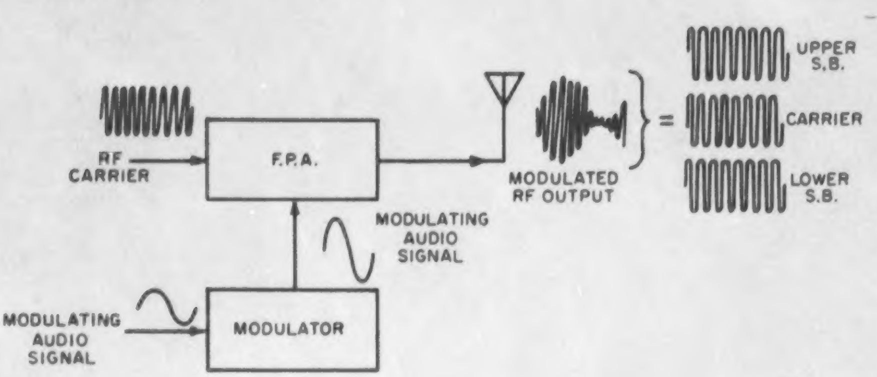
Those side frequencies that are lower in frequency than the carrier are referred to collectively as the lower sideband. The lower sideband is an inverted replica, or mirror image, of the modulating wave. The lowest modulating frequency (A) is represented by the highest frequency in the lower sideband (B), and the highest modulating frequency (G) is represented by the lowest frequency in that sideband (H). Despite this frequency inversion, the lower sideband is an example of the information contained in the modulating wave being translated to a higher part of the frequency spectrum.

When both the upper and lower sidebands are present and they contain identical information, the waveform is known as DOUBLE SIDEBAND (DSB).

Whenever a modulating frequency changes in amplitude, that change is reflected by a corresponding change in the amplitude of the side frequencies produced by it. There is also a change in the frequency content of each sideband whenever a change occurs in the frequency content of the modulating wave. For example, in standard voice transmissions, the combination of frequencies being produced by the speaker's vocal cords is constantly changing. Therefore, there is also a continuous change in the side frequencies produced. Figure 3-13 shows the output of an AM transmitter being modulated with voice variations. The alternate adding and canceling effects of the voice sine waves on the carrier "shape" the carrier, or envelope, at the output.

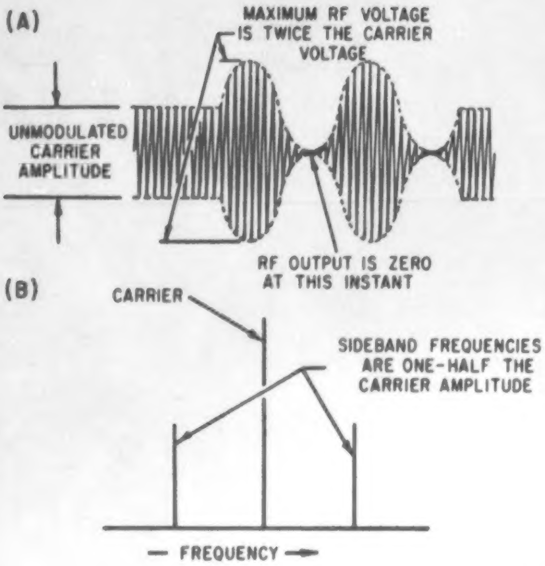
Percent Of Modulation

The depth or degree of modulation is defined in terms of the maximum permissible amount of modulation. The modulation envelope in figure 3-14 shows the conditions for 100% modulation. For this degree of modulation, the voltage of the audio signal, at its peak, must be equal to the supply voltage to the final PA. Under this condition, the RF output voltage will reach zero on the negative peak of the modulating signal and will rise to two times the amplitude of the unmodulated carrier on the positive peak of the modulating signal.


RF CARRIER
F.P.A.
MODULATING AUDIO SIGNAL
MODULATOR
MODULATING AUDIO SIGNAL
MODULATED RF OUTPUT
=
UPPER S.B.
CARRIER
LOWER S.B.

179.419

Figure 3-13.—Output of AM transmitter.


(A)
MAXIMUM RF VOLTAGE IS TWICE THE CARRIER VOLTAGE
UNMODULATED CARRIER AMPLITUDE
RF OUTPUT IS ZERO AT THIS INSTANT
(B)
CARRIER
SIDEBAND FREQUENCIES ARE ONE-HALF THE CARRIER AMPLITUDE
— FREQUENCY —

76.96

Figure 3-14.—Conditions for 100% modulation.

When analyzed, the modulation envelope in part (A) of figure 3-14 is found to consist of a carrier and two sidebands as shown in part (B). Since for 100% modulation, the peak audio modulating voltage is approximately equal to the peak RF voltage, the combined sideband voltage is equal to the carrier voltage. Because the sideband voltage is divided between two sideband frequencies, at 100% modulation each side frequency has an amplitude equal to one-half the amplitude of the carrier.

Although it is desirable to operate a transmitter at 100% modulation in order to inject a maximum amount of energy into the sidebands, this ideal condition is seldom possible when a carrier is modulated by voice. The reason for this is the great and rapid fluctuations in amplitude that the voice normally contains. When the modulator is properly adjusted, the loudest parts of the transmission will produce 100% modulation. The quieter portions of the signal will produce lesser degrees of modulation.

In order to measure degrees of modulation less than 100%, it is convenient to use a MODULATION FACTOR (M) to indicate the relative magnitude of the RF carrier and the audio modulating signal. Numerically, the modulation factor is as follows:

$$M = \frac{Em}{Ec}$$

where: M = The modulation factor

Em = The peak, peak-to-peak, or RMS value of the modulating voltage

Ec = The carrier voltage in the same units as Em

To illustrate the use of this equation, assume that a carrier wave having a peak amplitude of 400 volts is modulated by a 3 kHz sine wave having a peak amplitude of 200 volts. The modulation factor is:

$$M = \frac{Em}{Ec}$$

$$M = \frac{200}{400}$$

$$M = 0.5 - \text{MODULATION FACTOR}$$

If the modulation factor is multiplied by 100, the resultant quantity is the PERCENT OF MODULATION (%M):

$$\%M = \frac{Em}{Ec} \times 100$$

Where: $Em = 200$ volts
$Ec = 400$ volts

The percent of modulation is:

$$\%M = \frac{Em}{Ec} \times 100$$

$$\%M = \frac{200}{400} \times 100$$

$$\%M = 0.5 \times 100$$

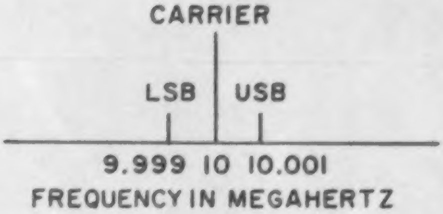
$$\%M = 50\%.$$

A transmitter is normally rated according to the amount of UNMODULATED CARRIER POWER it is designed to deliver to an antenna. At 100% modulation, the sidebands contain one-half as much power as the unmodulated carrier. If we were to reduce the percent of modulation to one-half of its original value, the sideband power decreases to one-fourth the amount obtained at 100 percent modulation. This shows the importance of a high percent of modulation. As you will see later in this chapter, the amount of power contained in sidebands is very important.

SINGLE-SIDEBAND (SSB) TRANSMITTER

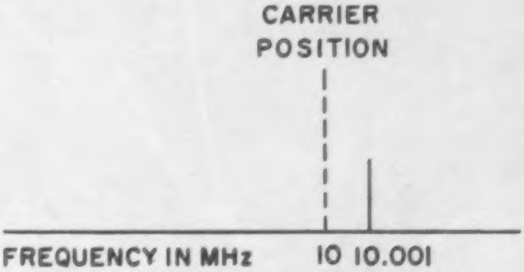
It was shown that an AM signal may be considered to consist of a carrier, an upper sideband, and a lower sideband. The spectrum analyzer representation of an RF carrier modulated by a single audio frequency is shown in figure 3-10. It should be recalled that a more complex waveform, such as speech, would create more frequencies in the sidebands.

The intelligence carried by an AM signal is contained in both sidebands. The amplitude of the intelligence is represented by the amplitude of either sideband, and the frequency of the intelligence is the difference between the carrier frequency and the sideband frequency. Since the intelligence contained in one sideband is a duplicate of the intelligence contained in the other sideband, only one sideband is required for communication. The other sideband may be eliminated by the use of filtering. As the carrier is totally unnecessary for the transmission of intelligence, it too may be filtered out. However, such communication depends upon the reinsertion of the carrier at the receiver in order to achieve the properly demodulated frequencies. This particular sideband system is referred to as Single Sideband Suppressed Carrier (SSBSC) communication. Figure 3-15 shows an AM spectrum analyzer presentation. Figure 3-16 is a spectrum analyzer presentation of a single sideband signal.



179.440

Figure 3-15.—AM Spectrum Analyzer presentation.



179.441

Figure 3-16.—SSB Spectrum Analyzer presentation.

The upper sideband has been chosen in the illustration for transmission. However, either sideband could have been used.

Single-Sideband

Now that you know basically what is meant by the term "SSB", let's take a look at some of the advantages of it. One advantage of single sideband is reduced bandwidth requirements. If a double-sideband signal requires 6 kHz for transmission, the same intelligence can be transmitted in only 3 kHz by eliminating one sideband. This 50% reduction in the required bandwidth is extremely valuable in conserving the overcrowded HF spectrum, where the number of available communication channels is severely limited.

The second advantage of single sideband is the conservation of power. In DSB transmissions, about two-thirds of the transmitter output power goes into the carrier and about one-sixth into each sideband. When one sideband is eliminated, the power it would have received can be put into the remaining sideband, which will then contain about one-third of the total power. The type of signal that results from eliminating one sideband but leaving the carrier undiminished is known as SINGLE SIDEBAND FULL CARRIER.

The main function of the carrier is to provide a means by which an information wave can be propagated up into the desired portion of the frequency spectrum. The carrier itself contains none of the intelligence, but it is needed at the receiver to aid in demodulation (recovery of the intelligence) and to provide a signal for automatic receiver gain control. There is, however, no need for the carrier to be at its full power level, and it is often greatly reduced. This is referred to as SINGLE SIDEBAND REDUCED CARRIER. This allows the amount of power taken from the carrier to be added to the intelligence contained in the sideband.

In order to completely eliminate the need for the carrier in the demodulation process, SSB receiving equipment generates a signal of the same frequency as the carrier, reinserts the carrier, and demodulates the result to obtain the original modulating signal. Therefore, there is no longer any point in transmitting the carrier. It can be eliminated at the transmitter after being used in the process of increasing the frequency of the intelligence sideband. All of the radiated power can then be added to the sideband being transmitted. As was mentioned previously, this is known as Single Sideband Suppressed Carrier.

Whenever one of the duplicate sidebands of a double sideband signal is discarded, the position formerly occupied by the discarded sideband can be used to transmit a second, but independent, sideband on the same carrier. The upper sideband is produced by one information source, and the lower sideband is produced by a second information source. Since the two sidebands are separate single sidebands sharing one carrier, such a transmission is referred to as INDEPENDENT SIDEBAND or DOUBLE SINGLE SIDEBAND. Independent sideband can be transmitted with full, reduced, or suppressed carrier.

The advantages of SSB communications are as follows:

(1) Minimization of distortion: In conventional AM, the two sidebands and the carrier must arrive at the receiver with the same phase relationship as when they were transmitted. If not, the received signal may be fuzzy and distorted. With suppressed carrier SSB, however, these problems are minimized because only one sideband is transmitted.

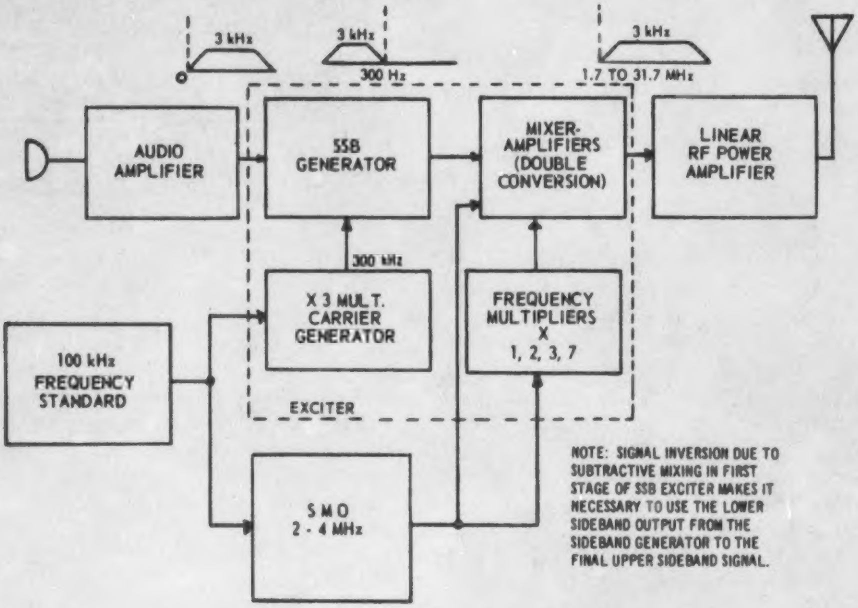
(2) Increased effective power: With suppressed carrier SSB, virtually all of the transmitted power goes into the sideband carrying the intelligence. This gives SSB much greater range, or distance capability.

(3) Double the number of channels: In suppressed carrier SSB, the number of channels using the same frequency in the spectrum is doubled.

(4) Reduction of interference: In normal voice transmissions, using AM, the carrier remains on the air as long as the "push-to-talk" button is depressed. In SSB, as soon as the individual stops speaking, talk power in the sideband leaves the air. Whenever two carriers are keyed simultaneously in AM, squeals and howls may result. This is caused by two carriers heterodyning together at the receiving end. In SSB, even though two stations key simultaneously, it may be possible for the receiving station to read through the interfering station.

Functional SSB Transmitter

Figure 3-17 shows a functional block diagram of a basic SSB transmitter. The input signal may be any desired intelligence signal and may cover


3 kHz
3 kHz
300 Hz
3 kHz
1.7 TO 31.7 MHz
AUDIO AMPLIFIER
SSB GENERATOR
MIXER-AMPLIFIERS (DOUBLE CONVERSION)
LINEAR RF POWER AMPLIFIER
300 kHz
X 3 MULT. CARRIER GENERATOR
FREQUENCY MULTIPLIERS X 1, 2, 3, 7
100 kHz FREQUENCY STANDARD
EXCITER
SMO 2 - 4 MHz

NOTE: SIGNAL INVERSION DUE TO SUBTRACTIVE MIXING IN FIRST STAGE OF SSB EXCITER MAKES IT NECESSARY TO USE THE LOWER SIDEBAND OUTPUT FROM THE SIDEBAND GENERATOR TO THE FINAL UPPER SIDEBAND SIGNAL.

179.445

Figure 3-17.—Basic block diagram of an SSB transmitting system.

all or any part of the frequency range between .1 and 6 kHz.

The SSB generator produces the SSB signal at an intermediate frequency (IF). To produce the SSB, a double sideband (DSB) signal is generated by the generator. It is then passed through a highly selective filter to reject one of the sidebands. These filters may be either crystal or mechanical.

The generated SSB signal is passed through mixers and amplifiers where it is converted to the transmitted RF. A SSB system without a pilot carrier demands an extremely stable frequency system. Therefore, the frequency standard and stabilized master oscillator (SMO) are extremely important.

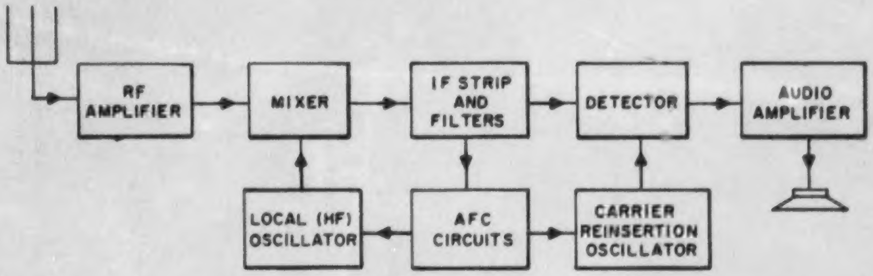
The standard frequency is obtained from a highly stable crystal oscillator. The crystal oscillator is very sensitive to temperature variations; therefore, it is housed in what is referred to as an "oven". This oven has a heat-sensitive network that indicates and corrects any temperature variation in the crystal network. This is done electronically and serves to maintain the stability of the master oscillator.

The carrier generator provides the IF carrier used to produce the fixed IF SSB signal, and the SMO provides the necessary conversion frequencies to produce the RF SSB signal. The frequencies derived from these two units are developed from the single standard frequency so that the stability of the standard frequency prevails throughout the SSB system. The 2 to 4 MHz frequency range of the SMO is a very practical range for obtaining high oscillator stability. The 300 kHz fixed IF is the optimum operating frequency for the filter required in the SSB generator.

The output of the SSB generator and carrier generator are mixed and amplified, then fed to an RF amplifier that amplifies the signal, and routed to the antenna for radiation into space. The frequency accuracy requirements for single sideband communications are very precise when compared to most other communication systems. A frequency error in carrier reinsertion of 20 Hz or less will give good voice reproduction. Errors of only 50 Hz result in noticeable distortion. This is considered the maximum error allowable in SSB.

SSB Receivers

Figure 3-18 shows a block diagram of a basic SSB receiver. A basic SSB receiver is not significantly different from a conventional superheterodyne AM receiver. However, a special type



179.442

Figure 3-18.—Basic SSB Receiver.

of detector and a carrier reinsertion oscillator must be used. The carrier reinsertion oscillator must insert a carrier in the detector circuit at a frequency which corresponds almost exactly with the relative position of the carrier in the original spectrum. The filters used in SSB receivers serve several purposes. As was previously stated, many SSB signals may exist in a small portion of the frequency spectrum. Filters supply the selectivity necessary to adequately receive only one of the many signals which may be present. They may also select USB or LSB operation as well as reject noise and other interference.

The oscillators in a SSB receiver must be extremely stable. In some types of SSB transmission, a frequency stability of plus or minus 2 hertz is required. For simple voice communications, a deviation of plus or minus 50 hertz may be within tolerance.

SSB receivers may employ additional circuits which enhance frequency stability, improve or provide automatic gain control (AGC). The circuits contained in figure 3-18 will be found in all single sideband receivers.

The need for extreme frequency stability may be understood if you consider the fact that a small deviation in local oscillator frequency, from the correct value, will cause the mixer to be displaced from its correct value. In double sideband AM reception this is not too damaging, since the carrier and the sidebands are all present and will all be displaced an equal amount. Therefore, the relative positions of the carrier and sidebands will be retained. However, in SSB reception, there is no carrier present in the incoming signal.

The carrier reinsertion oscillator frequency will be set to correspond to the IF frequency of the carrier if a carrier were present. The carrier reinsertion frequency is determined by the local oscillator frequency.

The detector most commonly used for SSB reception is the "product" detector. It is so called because under ideal operating conditions, its output amplitude is proportional to the product of the amplitude of the reinserted carrier and the SSB signal. The IF signal and the reinserted carrier are heterodyned in the detector. The reinserted carrier amplitude must be considerably higher than the IF amplitude. A carrier that is too small in relative amplitude would result in distortion of the output signal.

FREQUENCY MODULATION

Intelligence to be transmitted may be superimposed on the carrier in the form of changes in the frequency of the carrier. This type of modulation is known as FREQUENCY MODULATION. The carrier frequency can be varied a small amount on either side of its average, or assigned, value by means of an audio frequency modulating signal. The amount the carrier is varied depends on the amplitude of the modulating signal. The rate at which the carrier frequency is varied depends on the frequency of the modulating signal. The amplitude of the RF carrier remains constant with or without modulation.

The most simple method of establishing frequency modulation is to have a microphone connected into the oscillator circuit of the transmitter. When you speak into the microphone circuit at a momentarily low frequency, the oscillator frequency is changed only a few times

81

per second. If the sound waves are higher, the oscillator frequency is changed more times per second. When the sound waves have low amplitude, the extent of the oscillator frequency change is small. Thus, the frequency of the af signal determines the number of times per second (RATE OF DEVIATION) that the oscillator frequency changes. The amplitude of the af signal determines the extent of the oscillator frequency change (DEGREE OF DEVIATION). Figure 3-19 shows a basic block representation of an audio signal being fed into the oscillator input circuits. As you can see at the output, the oscillator frequency is slightly different because of the modulating frequency.

FM Sidebands

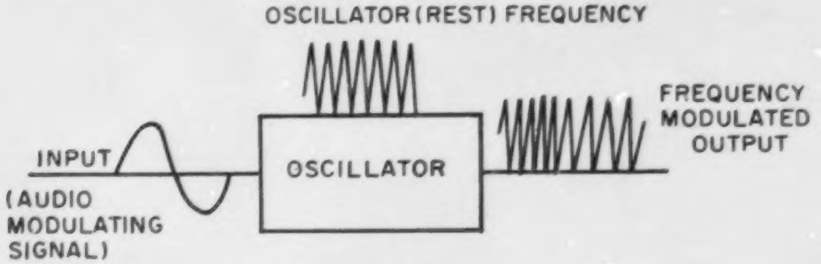
During the process of frequency modulation, just as during amplitude modulation, new frequencies, called sideband frequencies, are produced above and below the unmodulated carrier frequency. These sideband frequencies contain the signal intelligence, as in amplitude modulation, and combine with the unmodulated carrier to produce the modulation carrier previously described.

The significant difference between AM and FM sideband frequencies is the number produced. If you recall, in amplitude modulation, two sidebands are produced for every modulating frequency. One of these sideband frequencies is equal to the sum of the modulating and carrier frequencies and is above the carrier frequency. The other is equal to the difference between the modulating and carrier frequencies and is below the carrier frequency. In FM, each modulating frequency produces a similar pair of sum and difference sideband frequencies. However, in addition to the basic pair, a theoretically infinite number of additional sideband frequencies are produced. These additional frequencies are equal to whole number multiples of the basic pair. These exact multiples of the basic frequency are called HARMONICS. For example, if we distort a 3 kHz sinewave, multiple sine waves of 6 kHz, 12 kHz, 15 kHz, etc. will be created. The original frequency of 3 kHz is referred to as the 1st harmonic, or the FUNDAMENTAL FREQUENCY. Double that frequency is the 2nd harmonic; three times that is the 3rd harmonic; and so on. Although theoretically these sidebands extend outward from the carrier indefinitely, only a limited number of them contain significant power to be heard. The further from the fundamental frequency that the harmonic is, the less power it will have.

You will recall that in amplitude modulation, the amplitude of the sideband frequencies, or the power contained in them, was independent of the amplitude of the unmodulated carrier and dependent only on the amplitude, or power, of the modulating signal. In FM, the situation is different. The sidebands derive their power from the carrier, which means that the unmodulated carrier component of an FM wave has less power, or a smaller amplitude, after modulation than it does before modulation. The amount of power removed from the carrier and placed in the sidebands depends on the modulating frequencies and the maximum deviation of the carrier. It is possible under certain conditions for the carrier power to be zero, with all the power contained in the sidebands. This, of course, is the ideal situation since the carrier itself contains no intelligence.

FM Bandwidth

Previously, we said that the term "bandwidth" meant the entire range of frequencies



179.428

Figure 3-19.—Basic process of frequency modulation. (FM).

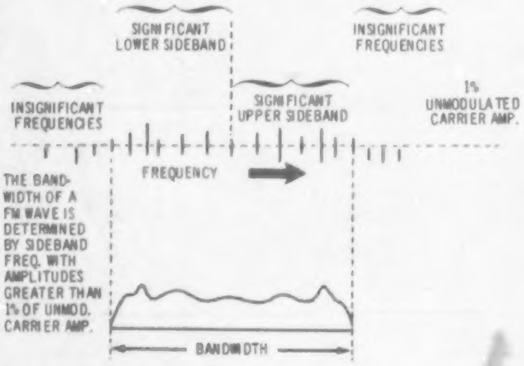
in a modulated wave. Because of the many sideband frequencies contained in FM waves, only the significant frequencies are included in its bandwidth. The bandwidth of an FM wave is the frequency range between the extreme upper and the extreme lower sideband frequencies whose amplitudes are 1% or more of the unmodulated carrier amplitude.

When an FM wave has a very wide bandwidth, it is called WIDEBAND FM and requires the use of carrier frequencies much higher than those used for AM carrying similar intelligence. These high carrier frequencies are necessary so that a maximum number of FM waves can be transmitted by radio without interfering with each other. In wideband FM, many of the sideband frequencies are included in the bandwidth, as shown in figure 3-20.

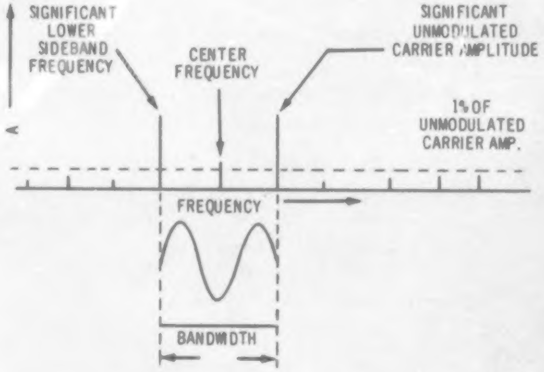
It is possible, by limiting the maximum deviation of the FM carrier, to produce FM having the same bandwidth as an AM wave carrying the same intelligence. This is called NARROWBAND FM (see figure 3-21). While this process causes some distortion of the intelligence, it allows carrier frequencies to be used that are lower than some required for wideband FM.

The bandwidth of a modulated wave is important for two reasons: (1) It determines how much space or room in the radio frequency spectrum the wave will occupy, and (2) it determines the range of frequencies over which the electronic circuits used to receive and process the wave must be capable of operating.

As far as the radio frequency spectrum is concerned, all of the modulated waves transmitted by radio in any one geographical area must occupy different places in the spectrum, otherwise they will interfere with each other. For example, the lower frequencies of a modulated wave with a 100 MHz carrier and an 8 kHz bandwidth would overlap and interfere with the upper frequencies of a 99 MHz carrier with an 8 kHz bandwidth. You can see that interference between radio waves can be avoided either by reducing bandwidths or by moving carrier frequencies farther apart. However, if bandwidths are made too narrow, distortion of the intelligence carried by the wave will result since many of the sidebands which contain the intelligence will be eliminated. On the other hand, if carrier frequencies are too far apart, a very limited number of radio waves would completely fill the radio spectrum.


SIGNIFICANT LOWER SIDEBAND
INSIGNIFICANT FREQUENCIES
INSIGNIFICANT FREQUENCIES
SIGNIFICANT UPPER SIDEBAND
1% UNMODULATED CARRIER AMP.
FREQUENCY
THE BANDWIDTH OF A FM WAVE IS DETERMINED BY SIDEBAND FREQ. WITH AMPLITUDES GREATER THAN 1% OF UNMOD. CARRIER AMP.
BANDWIDTH

179.431
Figure 3-20.—Spectrum of WIDEBAND FM.


SIGNIFICANT LOWER SIDEBAND FREQUENCY
CENTER FREQUENCY
SIGNIFICANT UNMODULATED CARRIER AMPLITUDE
A
1% OF UNMODULATED CARRIER AMP.
FREQUENCY
BANDWIDTH

179.432
Figure 3-21.—Spectrum of NARROWBAND FM.

Modulation Index

In FM, the modulation index is the ratio of the carrier's frequency deviation to the modulating frequency. Expressed as an equation:

$$M = \frac{Fd}{Fm}$$

where: M = Modulation index

Fd = Frequency deviation of the carrier

Fm = Frequency of the highest modulating signal

A carrier's frequency deviation is the amount of "swing" or deviation, in kilohertz or megahertz, caused by modulation with audio.

For example, a maximum deviation of 75 kHz on the frequency bands up to 108 MHz can be interpreted in terms of percent by referring to this carrier swing as a limit and saying that 75 kHz is 100 percent modulation when the carrier is allowed to swing to this maximum.

Overmodulating or overdeviating will occur if the maximum carrier swing is exceeded. Transmission is not particularly affected, but audio distortion may result. Moreover, the bandwidth or part of the communication frequency band occupied by the carrier then exceeds the limits assigned to it by law.

Percent Of Modulation

In AM, 100 percent modulation exists when the amplitude of the envelope varies between zero and twice its normal unmodulated value. There is a corresponding increase in power of 50 percent.

In FM, 100 percent modulation has a different meaning. The af signal varies only the frequency of the oscillator. Therefore, there is a constant power input at the transmitting antenna, regardless of the degree of modulation. A modulation of 100 percent simply means that the carrier is deviated in frequency by the full permissible amount. For example, an 88 MHz FM station has 100 percent modulation when its audio signal deviates the carrier 75 kHz above and 75 kHz below the 88 MHz carrier, when 75 KHz is assumed to be the maximum permissible frequency swing. For 50 percent modulation, the frequency would be deviated 37.5 kHz above and below the resting frequency.

TRANSMITTER TROUBLESHOOTING

Visual checks and signal tracing used to troubleshoot receivers are not used as such when you troubleshoot transmitters. Because of the high voltages present in transmitters, it is not safe to work with them while they are energized. Therefore, an alternate method is provided by means of meters mounted on the front panels of transmitters. These front panel meters are permanently wired (or may be switched) into various transmitter circuits, and most basic troubles can be isolated by using only these meters.

Safety Precautions

Most circuits in transmitters operate with very high voltages. Therefore, it is dangerous to reach inside a transmitter to measure voltages or to change a part while the power is on. This may seem obvious to you, but it is a much violated rule.

Navy transmitters are designed to protect you from accidents that could happen through carelessness. They have access doors through which you can remove bad components. If you open one of these doors when the transmitter is on, the power should turn off automatically. The doors operate switches, called INTERLOCKS, which are connected between the on/off switch and the circuits of the transmitter. When an access door is open, the interlock is opened and no power is applied to the transmitter. Because of the important role played by an interlock, unauthorized shorting out of an interlock is a very dangerous practice.

There is still a possibility of a serious shock, even when you turn the power off before reaching into a transmitter. A fault in the circuit may have prevented a capacitor from discharging, and your body may provide a discharge path.

As a safeguard against a shock due to charged circuit capacitors, a shorting bar, consisting of a metal rod with a wooden handle, is used. The metal end is connected to the ground of the transmitter through a copper braid. Before putting your hand inside, probe about with the shorting rod, touching every point which might conceivably be charged. If nothing is charged, this procedure costs you about 30 seconds; if something is charged, the shorting rod discharges it, and the procedure saves you from injury or death.

CHAPTER 4

BASIC RECEIVER THEORY

Just as we must have transmitters to transmit radio waves, we must also have communication receivers to receive these radio waves. Whether the transmitted signal consists of encoded characters and intelligence or is amplitude modulated, we must have a receiver capable of handling that particular type of transmission and converting it into a useful output.

It is necessary that communication personnel have an understanding of basic receiver theory. Not only does this understanding enhance your ability to pass advancement examinations, but it also provides your command with a more proficient watchstander, capable of recognizing basic trouble-symptoms and correcting them before they become major problems.

The purpose of this chapter is to give you an overall view of the manner in which a receiver converts the electromagnetic wave received by the antenna into the type of energy that satisfies communication requirements. In other words, if we are transmitting AM, the receiver must convert the received energy into intelligible sound. If the transmitted signal is a fleet teletype broadcast, the receiver must convert the received energy into teletypewriter functions to print out the desired characters. We will accomplish our study of basic reciever theory by separating the receiver into blocks with each block representing a main section of the receiver. There are many types of receivers, each with specific functions. However, for the sake of simplicity, we will confine our study to AM. Whether the receiver is an AM, SSB, or teletype control type, the functions of basic circuits remain the same.

Origin Of Receiver Input

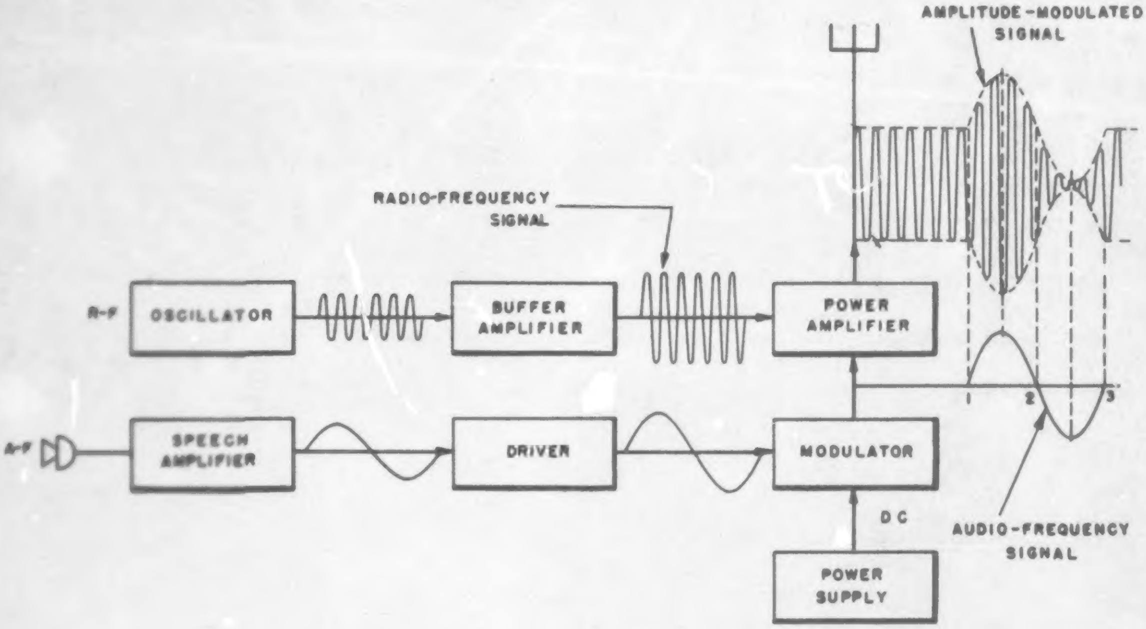
The purpose of a receiver is to convert the electromagnetic wave from the transmitting antenna into usable energy. Before entering into a discussion of the manner in which the receiver accomplishes this, let's briefly review the origination of the transmitted wave. Figure 4-1 illustrates the block diagram of a basic transmitter and the nature of the input and output of each major section. In AM, the microphone converts the sound waves into an electrical signal which varies in frequency and amplitude in accordance with the original sound. Since the signals from the microphone are very weak, they are fed to the modulation section, consisting of a speech amplifier, driver, and modulator. This section increases the amplitude to a level suitable to be used as an input to the power amplifier.

The power amplifier in the RF unit has two inputs: One is the audio signal from the modulator and the other is the constant amplitude radio frequency signal from the oscillator. The output of the oscillator is called the "carrier" frequency. In the power amplifier, the audio signal (intelligence) is impressed on the carrier. The output of the power amplifier is a modulated RF signal which is then fed to the antenna.

The antenna radiates the modulated RF signal in the form of electromagnetic waves. This electromagnetic wave will now be used as the input to the receiver.

Receiver Functions

An AM receiver processes amplitude modulated signals received by its antenna and delivers as an output a reproduction of the original signal that modulated the RF carrier at the transmitter. The signal can then be applied to some reproducing device, such as a loudspeaker or a set of headphones. Actual AM receivers vary widely in complexity. Some are very simple but contain a relatively large number of circuits.



13.53

Figure 4-1.—Typical Radiotelephone Transmitter (AM).

A receiver must perform certain basic functions in order to be useful. These functions, in order of their performance, are reception, selection, detection, af amplification, and reproduction.

RECEPTION involves having the transmitted electromagnetic wave cut across the receiver antenna in such a manner as to induce a voltage in the antenna circuits.

SELECTION involves being able to select a particular station's frequency from all the transmitted signals that happen to be induced in the receiver's antenna at a given time.

DETECTION is the action of separating the low frequency intelligence from the high frequency carrier.

AMPLIFICATION of af involves amplifying the low frequency intelligence to the level required for the operation of the reproducer.

REPRODUCTION is the action of converting the electrical signals to sound waves which can then be interpreted by the ear, such as speech or music.

Sensitivity

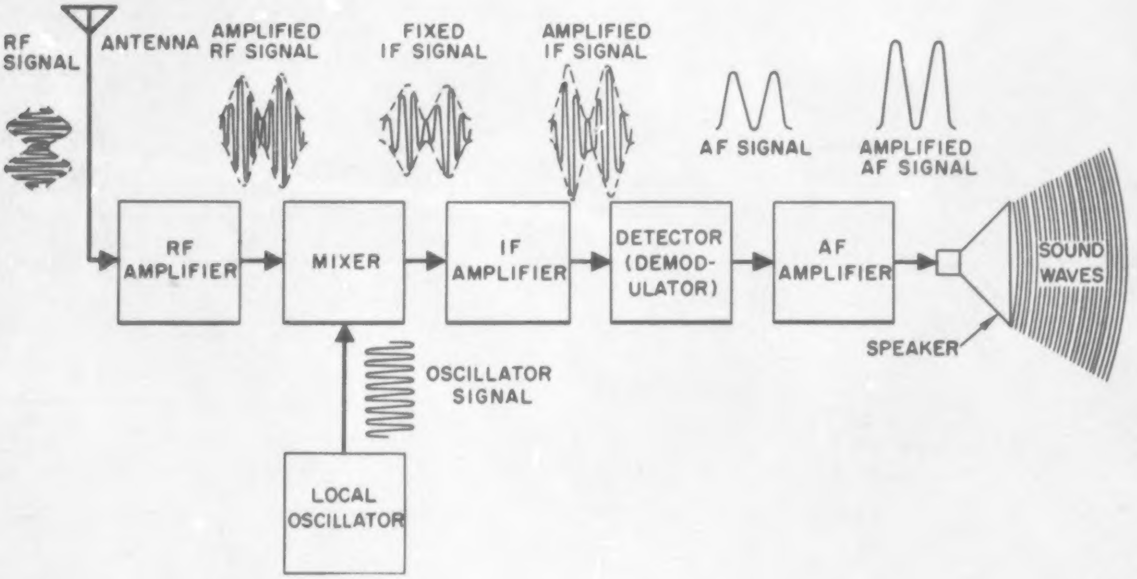
The ability of a receiver to reproduce the signal of a very weak station is a function of the receiver's SENSITIVITY. In other words, the weaker a signal that can be applied to a receiver and still achieve the same value of signal output, the better is that receiver's sensitivity rating.

Selectivity

The ability of a receiver to select and reproduce a desired signal from among several closely spaced stations or from among interfering frequencies is determined by the receiver's SELECTIVITY. In other words, the better a receiver is at differentiating between desired and undesired signals, the better is the receiver's selectivity rating.

THE SUPERHETERODYNE RECEIVER

The basic block diagram of a typical superheterodyne receiver is shown in figure 4-2. The diagram is shown in the order in which a signal passes through the receiver. Above the corresponding sections of the receiver are shown the waveforms of the signal at that point. Before going further, the term HETERODYNING must



76.25

Figure 4-2.—Superheterodyne Receiver, showing signal waveshape.

be defined in order to understand the operation of the superheterodyne receiver.

Actually, we could substitude the word "mixing" for heterodyning and mean the same thing. The principle, or process, of combining two or more frequencies and producing new frequencies is called mixing, modulating, beating, frequency conversion, or HETERODYNING.

In a superheterodyne receiver, amplifiers preceding the detector stage are tuned to one frequency called the INTERMEDIATE FREQUENCY (IF). The principle of frequency conversion by heterodyne action is employed to convert all frequencies throughout the receiver range to this intermediate frequency. This is advantageous in that the IF circuits may be more uniformly selective, uniformly high in gain, and uniformly of satisfactory bandwidth to contain all of the desired sideband components associated with the amplitude-modulated carrier.

Refer to figure 4-2. The RF signal received by the antenna passes first through an RF amplifier where the amplitude of the signal is increased. A locally generated unmodulated RF signal of constant amplitude is then mixed with the carrier frequency in the mixer stage. This constant amplitude signal is generated by the local oscillator.

The mixing or heterodyning of these two frequencies produces an intermediate frequency signal which contains all of the intelligence or modulation of the original carrier signal. The intermediate frequency is then amplified in the several intermediate frequency amplifiers and fed to a conventional detector for recovery of the audio signal.

The detector demodulates the signal (recovers the audio) and sends it to the af amplifiers. Then the af is fed to a set of earphones or to a loudspeaker.

The superheterodyne receiver is used as the basis for our study because nearly every Navy receiver operates on the principle of heterodyning to produce a fixed IF frequency.

Antenna Section

The antenna section precedes the first RF amplifier. As shown in figure 4-2, all of the signal processing starts here. The electromagnetic waves propagated from the antennas of the transmitters cut across the receiving antenna and induce very small a.c. voltages in the receiver antenna. These small a.c. voltages are fed to the antenna circuits located at the input of the receiver itself.

Frequency-selection circuits, which are part of the input antenna circuits, determine the signal frequency that will be passed on to the RF amplifier circuits to be processed and used. It should be pointed out that there are literally millions of different signals present in the atmosphere at any one time, many of them cutting across the receiving antennas at the same time. If it weren't for the frequency-selection circuits located at the input of the receiver, all that would be heard on the receiver would be static and a multitude of stations "piled" on top of each other. The frequency that you select at the front panel of your receiver normally determines the frequency or frequencies that the selection circuits will allow to pass on to the rest of the circuits for processing.

It should be remembered that the amplitude modulated signal as it leaves the transmitter with a single audio frequency as the intelligence is actually composed of energy at three distinct frequencies. These frequencies are the carrier frequency and two (upper and lower) sideband frequencies. The separation between the maximum limits of the upper and lower sideband frequencies constitutes the bandwidth of the transmitted signal, while the separation between either sideband and the carrier is equal to the intelligence frequency. To perform its function properly, the frequency selection circuit must pass both sidebands.

RF Amplifier

The RF stage amplifies the small a.c. voltages induced in the antenna by the electromagnetic wave from the transmitting antenna. Using the tuned frequency selection circuits located between the antenna and the input of the RF amplifier permits selection of the desired station frequency from among the many present at the antenna.

Besides amplifying the RF signal, the RF amplifier has other important functions. For example, it isolates the local oscillator from the antenna-ground system. If the antenna were connected directly to the mixer stage, a part of the local oscillator frequency might be radiated into space. This could be harmful to ship's movements since this signal would violate radio silence, when it is in effect, as well as enable potential enemies to track the ship via sensitive direction-finding equipment. For this reason and others, Navy superheterodyne receivers are normally provided with at least one RF amplifier stage.

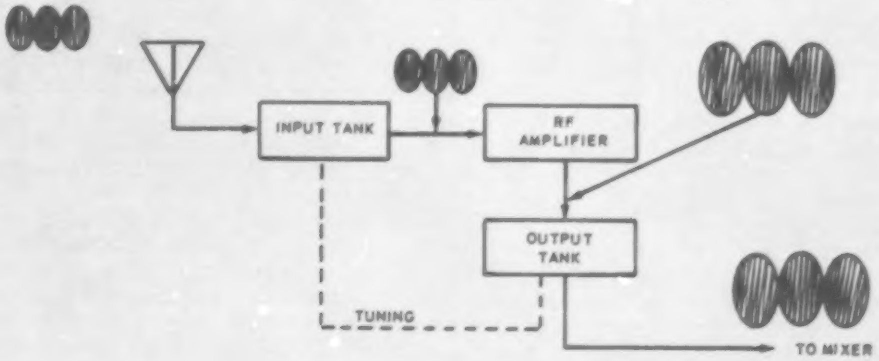
There are two types of RF amplifiers: TUNED AND UNTUNED. Untuned amplifiers are rarely, if ever, used in communication receivers. Tuned amplifiers normally provide very high amplification over a small range of frequencies or at a single frequency. Naturally, superheterodyne receivers use tuned RF amplifiers.

The RF stage, which is also called the "pre-selector", is also important in improving the signal-to-noise ratio of receivers. A poor RF amplifier will enable the equipment to respond only to large input signals, whereas a good RF amplifier will bring in the weak signals above the self-generated receiver noise and, thus, permit reception which would otherwise be impossible. The self-generated noise is a result of the operation of the various components that make up each circuit within each stage of the receiver. For example, the mixer is a very noisy stage due to the heterodyning taking place within it.

The mixer stage generates the majority of receiver noise. This "noise" is in the form of voltage variations that are different in frequency, are out of phase with existing voltages, and tend to cancel and distort those frequencies and voltages necessary to proper receiver operation and signal processing. Enough RF amplification is needed, with a low noise level in the RF amplifier, to supply an adequate signal with a high signal-to-noise ratio for the input to the mixer stage. As a result, the signal level at the mixer input is the limiting factor in the ability of the receiver to reproduce an acceptable output with a weak signal input from the antenna.

The SELECTIVITY of the superheterodyne receiver is a measure of its ability to reject unwanted frequencies and pass the desired frequency. In the tuned preselector stage, this is normally accomplished by means of TANK circuits that are tuned to the desired operating frequency of the receiver. These circuits (figure 4-3) are the frequency-determining networks that allows the proper frequency to pass into the receiver for further processing.

The SENSITIVITY of the superheterodyne receiver is a measure of its ability to amplify weak signals. Naturally, this is accomplished primarily in the RF stage. The sensitivity of a receiver can be increased by increasing the number of RF amplifiers. Not only can sensitivity be increased, but to some degree we can also increase the selectivity by increasing the number

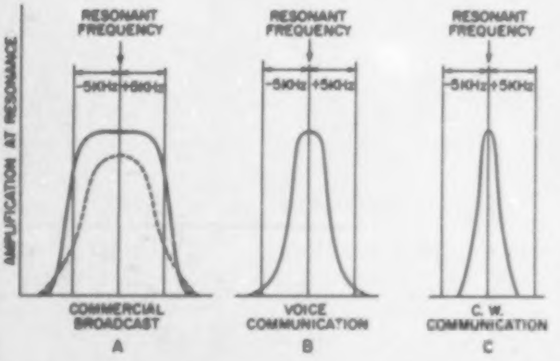


179.285

Figure 4-3.—RF amplifier and assoicated "tanks".

of RF amplifier stages. This is due to the tuned circuits that are part of each RF amplifier stage. These tuned circuits tend to reject unwanted frequencies at each RF amplifier stage and by the time that the signal is processed through, say, five stages of RF amplification, most unwanted signals will have been rejected. A selective receiver is said to tune "sharply". To explain this, refer to figure 4-4. We have shown relative tuning curves of a commercial station (A), a voice communication (B), and a CW communication (C). The "resonant" frequency is simply the center or carrier frequency and carries an upper and lower sideband of 5 kHz on each side of the carrier.

Carrier waves from commercial FM broadcast stations contain sideband frequencies that extend 5 kHz on either side of the carrier. If a station is transmitting on 1140 kHz, the complete carrier wave contains frequencies from 1135 to 1145 kHz. Therefore, the preselector circuits of the RF stage must be such that they have a bandwidth of at least 10 kHz in order to allow the carrier and sidebands to pass into the receiver for processing. If a receiver tunes too "sharply" (is too selective), some of the sideband frequencies are lost and the result will be distortion and garbling at the output of the receiver. The commercial broadcast curve shown in figure 4-4 (A) is OPTIMUM—"at its best". The top is broad and flat, indicating the preselector circuits pass the entire carrier and sidebands. The sides are steep, indicating maximum, uniform amplification over the entire passband. The broken line represents the tuning curve of most broadcast AM receivers. This broken line indicates that much of voice and music components are lost in the preselector circuits and are not reproduced by the set. The preselector circuits for most FM receivers is nearer that of the solid, unbroken line of figure 4-4 (A). Although this represents very good fidelity (more exact reproduction), it also indicates the frequency extravagance normally associated with FM in an already crowded frequency spectrum.



76.24

Figure 4-4.—Three types of tuning curves.

Although sharp tuning in the tuned circuits of the RF stages would make for poor listening in a home radio, it is desirable for military sets for the sake of frequency economy and reduction of interference. Figure 4-4 (B) and (C) indicate the normal operating bandwidth of preselector circuits in Navy receivers. Radiotelephone (AM) messages can be sent on frequencies that extend only 2 kHz on either side of the carrier. The voice may sound unnatural, but it can be understood. The CW sets tune so sharply that, unless a receiver operator is careful, he can turn his dial through the signal without even hearing it.

Mixer and Local Oscillator

The function of the mixer stage is frequency conversion by heterodyne action. The input to the mixer consists of two signals: The modulated RF signal coming from the RF amplifier stages and the unmodulated local oscillator signal. The local oscillator stage produces a constant amplitude sine wave of a frequency which differs from the desired station frequency (selected frequency) by an amount equal to the IF of the receiver.

In most superheterodyne receivers, the IF frequency is 455 kHz. This frequency that the IF circuits are tuned to accept. Therefore, the output of the mixer stage must be 455 kHz in order to further process the signal properly. The 455 kHz is a result of the mixing action (heterodyning) of the RF frequency being fed in from the RF amplifier and the frequency of the local oscillator.

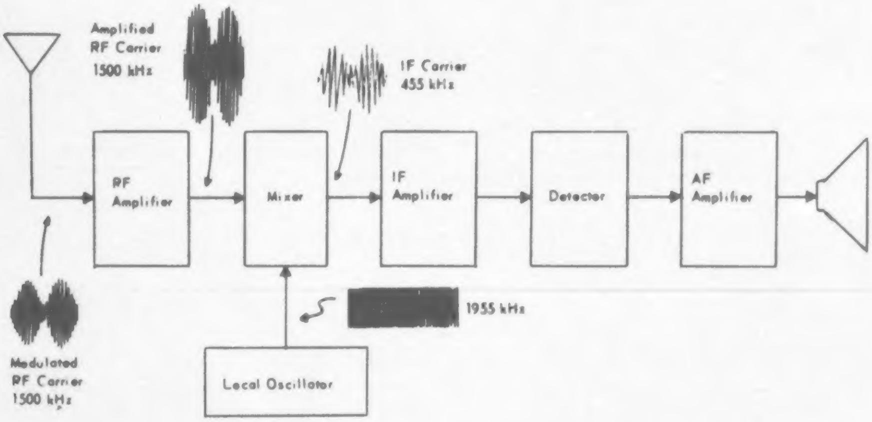
As a result of this heterodyning, the output of the mixer will contain four major frequencies. These four major frequencies are (1) the original signal frequency from the RF stage, (2) the local oscillator frequency, (3) the SUM of the RF and local oscillator stage frequencies, and (4) the DIFFERENCE between the RF and local oscillator stage frequencies.

Of the frequencies present in the output of the mixer stage, only the DIFFERENCE frequency will be used. The output circuit of the mixer stage contains a tuned circuit that is tuned to the difference frequency, or 445 kHz. The local oscillator may be operated at a frequency either above or below the preselected, desired frequency. The tuned circuits of both the RF stage and the local oscillator are variable but in direct proportion to each other. By this, we mean that the tuned circuits of these two stages are "ganged" on a common tuning shaft. As you vary the preselector circuits of the RF amplifier to determine the frequency to be passed and processed, you simultaneously vary the tuned circuits of the local oscillator and the output frequency of the local oscillator. Therefore, the difference between the RF stage and the local oscillator is always 455 kHz and contains all of the intelligence contained originally in the RF carrier.

Figure 4-5 shows another basic block diagram of a superheterodyne receiver with an input RF carrier frequency of 1500 kHz. The local oscillator is shown "tracking" at 1955 kHz, or 455 kHz above the carrier. The resultant difference is the IF carrier shown at the output of the mixer.

IF Amplifier

Superheterodyne receivers employ one or more IF amplifiers depending on design and quality of the receiver. The IF circuits are permanently tuned to the difference frequency



13.66

Figure 4-5.—IF "difference" frequency of 455 kHz.

between the RF signal and the local oscillator. As previously stated, all incoming signals are converted to the same frequency by the mixer, and the IF amplifier operates at only one frequency. The tuned circuits, therefore, are permanently adjusted for maximum signal gain consistent with the desired bandpass and frequency response. Practically all of the selectivity of a superheterodyne receiver is determined by the IF stages of amplification, aided by the selectivity already provided by the RF amplifiers.

In many ways the operation of the IF amplifier is similar to that of the RF amplifier. The signals, however, are at a lower frequency than those in the RF amplifier. Unlike the RF tuned circuits (whose frequency is tunable over a wide range), the tuned circuits used in IF amplifiers are fixed at a definite resonant frequency. Since they operate at a fixed band of frequencies, the IF amplifiers can be designed to provide optimum gain and bandwidth characteristics.

An additional function of the IF amplifier is to preserve all of the original modulating intelligence contained in the carrier. At this stage of signal processing, ALL of the amplitude modulated intelligence is still contained in the 455 kHz IF signal. All we have done is to amplify it. The output of the final IF amplifier is fed to the detector, or demodulator.

Detector

DETECTION, also called DEMODULATION, is the process of recreating original modulating frequencies (intelligence) from radio frequencies which are present in the IF signal. This is what happens in the detector stage of a superheterodyne receiver. The modulated IF of 455 kHz, which has been amplified, is "demodulated". All that is left, once the signal is processed through this stage, is the intelligence only. Refer back to figure 4-2. The signal has been reduced to the original modulation imposed at the transmitter and is now varying at an af (audio frequency) rate. These are the original amplitude modulations created by the voice of the person who originally spoke into the microphone at the transmitter. This af is a very small signal. Before it can be heard and used, it must be amplified.

AF Amplifier

The AF amplifier stage does just as its name implies: It amplifies the audio frequency fed to it from the detector stage. This is a necessary stage because we must be able to feed the af signal to headphones, converters, speakers, etc. The af stage is the final stage of the superheterodyne receiver.

RECEIVER CONTROL CIRCUITS

Every receiver employs control circuitry. The number of control circuits used by any one receiver varies, depending upon the type of receiver and what it was designed to do. However, there are control circuits common to most receivers. These common circuits accomplish the same thing in all cases regardless of the receiver in which they are located. Most of these control circuits are controlled from the front panel of the receiver. By having a basic knowledge of what these various circuits do, you can learn to distinguish those front panel controls on any receiver that control them. Front panel controls and switches vary from receiver to receiver, but control circuit functions do not.

Manual Gain Control (MGC)

As was previously mentioned, high sensitivity is one of the parameters of a good receiver. In some cases, however, high sensitivity can be a liability. For example, the signal received from a nearby transmitting station can be strong enough to overload the RF sections of a receiver. This causes the audio output to be distorted and less intelligible. Gain control of the RF section is used to overcome this problem. If gain control were not used, receiver sensitivity would have to be permanently decreased. With gain control, maximum sensitivity is realized, and weak input signals are provided with maximum amplification. When a strong input signal is received, the RF gain may be reduced to prevent overloading or "overdriving".

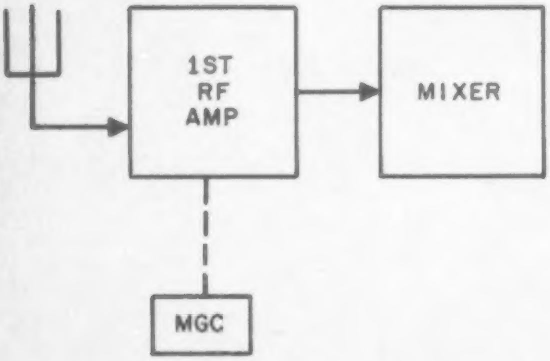
On the front panel of receivers, the manual gain control can usually be recognized by the word "manual", or "MGC", or "MANUAL-GAIN". It works much like the volume control does on your home radio in that as you vary the control, the output of the set can be clearly heard to increase or decrease in volume. In communication receivers, as you decrease the setting of the manual gain control in response to a too-strong signal that is overdriving your output to the point of distortion, you will notice that the signal becomes more intelligible.

The manual gain control circuit is normally installed in communications receivers as part of the first RF amplifier stage. Since it is the RF stages that are being overdriven, it makes sense to place the control circuit for manual gain in that stage. All that you are doing when you are turning the manual gain control knob on a receiver is varying the amplification factor of the RF stage.

Figure 4-6 is a block representation of the placement of the manual gain control circuit. Although the MGC circuit is helpful in controlling strong, overdriving signals, the disadvantage of this method is obvious. If the signal strength continues to vary, the gain control must be constantly adjusted. Instead, an automatic gain control circuit is employed by all communications receivers.

Automatic Gain Control (AGC)

As you already know, variations in the output volume of a receiver may result from variations in the input signal strength. These changes in input signal strength may occur as a result of simply changing stations or as a result of "fading" which is caused by changes in atmospheric conditions. Therein lies the function of an AUTOMATIC GAIN CONTROL (AGC), also referred to as an AUTOMATIC VOLUME CONTROL (AVC). This control circuit limits unwanted variations in the output of the receiver due to variations in strength of the received signal. As was previously mentioned, in order to maintain a constant output level, a receiver without AGC would require continuous manual readjustment to compensate for received signal changes.



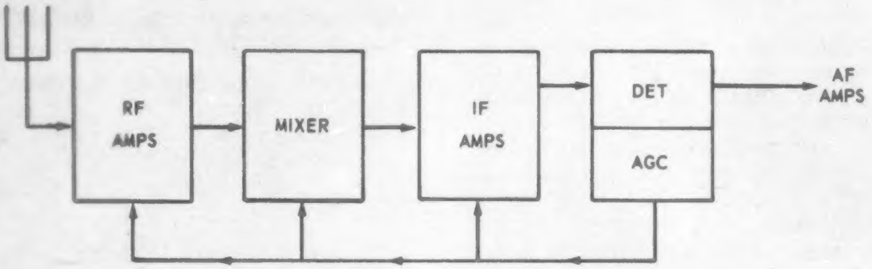
76.97
Figure 4-6.—Placement of the manual gain control circuit, (MGC).

Signals from stations operating at the same power level may not reach the receiver antenna with the same power because of differences in transmission distances, carrier frequencies, atmospheric conditions, and obstructions between the transmitter and receiver antennas.

The conclusion might be drawn that an AGC network is not necessary when the receiver is operating on a single station. However, this is not true because atmospheric conditions may cause the signal strength to fade in and out and vary, or the antenna may receive components of the signal which have traveled along different paths. For example, one component may travel from the transmitting antenna directly to the receiving antenna, and another may have been reflected from a distant object. The two signals will sometimes be in phase and at other times be out of phase, thus tending to reinforce or cancel each other. The result is a variation in signal strength at the receiver antenna which is called fading.

In a superheterodyne receiver, the detector circuit "demodulates" or separates the carrier and the intelligence. The output of the detector circuit also contains a d.c. component. This d.c. component is directly proportional to average modulated carrier amplitude. The AGC circuitry (figure 4-7) utilizes this d.c. component by filtering the detector output and applying a portion of the d.c. component to the preceding stages (figure 4-7). This AGC voltage is used to control the amplification of any or all of the stages preceding the detector stage.

The AGC voltage acts as a CONTROLLED DEGENERATIVE FEEDBACK. As can be seen by the block diagram in figure 4-7, this voltage is fed back from the detector stage. The AGC voltage controls the amplification factor of the amplifiers in the preselector stage. Basically, what happens is very simple. As the input signal to the RF stage increases, the signal at the detector will also increase, increasing the amount of AGC voltage being fed back from the detector. This greater feedback voltage will decrease the amplification factor of the RF amplifiers, thus tending to keep the input signal at a steady norm. The reverse happens when the input signal is very small. The AGC feedback voltage from the detector stage is also



179.358

Figure 4-7.—Automatic Gain Control, (AGC) feedback.

very small and the amplification factor of the RF amplifiers increases, thus allowing for higher amplification of weaker signals. A disadvantage of AGC is that even the weakest signals produce some AGC, causing a decrease in RF amplifier gain and, thereby, attenuating very weak signals even more.

Delayed Automatic Gain Control (DAGC)

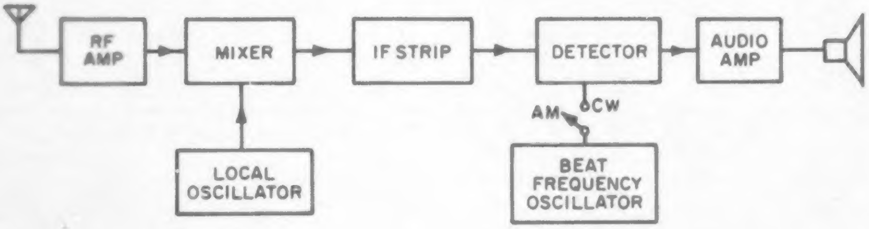
The disadvantage of automatic gain control, that of attenuating even the very weak signal, is overcome by the use of delayed automatic gain control. This type of gain control develops no AGC feedback until a certain received signal strength is attained. For signals weaker than this value, there is no AGC developed. For sufficiently strong signals, the delayed AGC circuit operates essentially the same as the ordinary AGC circuit.

Beat-Frequency Oscillator (BFO)

The beat-frequency oscillator (BFO) is necessary when CW signals are to be received because these signals are not modulated with an audio component. The action of the RF amplifier, mixer, local oscillator, and IF amplifier is the same for both CW and AM, but the CW signal reaches the detector as a single frequency signal with no sideband components. In order to produce an af output, it must be heterodyned (beat) with an RF signal of the proper frequency. This separate signal is obtained from an oscillator known as a beat frequency oscillator (BFO).

Figure 4-8 is a block diagram of a superheterodyne receiver capable of receiving and demodulating a CW signal. The IF signal is heterodyned with the BFO at the SECOND DETECTOR to produce an AF output. The second detector is used primarily because the first detector is normally used as the source of AGC.

If the intermediate frequency is 455 kHz and the BFO is tuned to 456 kHz or 454 kHz, the difference frequency of 1 kHz is heard in the output. Generally, the BFO is tunable from the front panel of the receiver. By varying this control, you are varying the output of the BFO and will normally notice a difference in the tone of the output signal as you do so.



179.467

Figure 4-8.—Placement of the Beat Frequency Oscillator, (BFO).

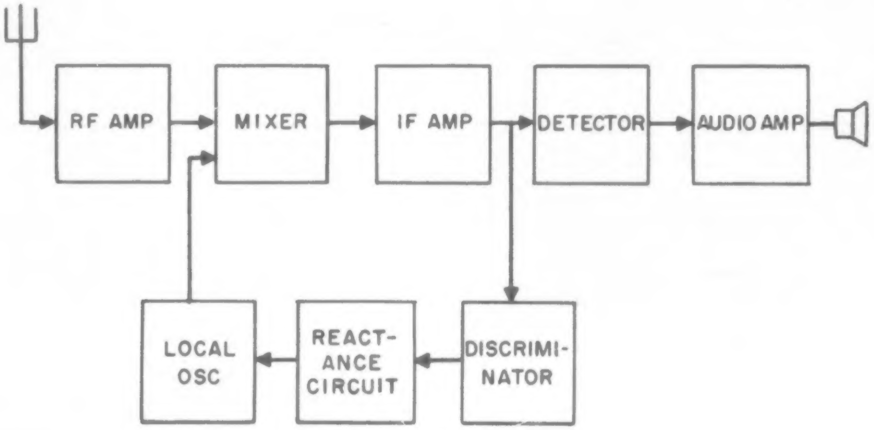
Silencer

A receiver's sensitivity is maximum when no signal is being received. This condition occurs, for example, when the receiver is being tuned between stations in the form of background noise picked up by the antenna. The noise is greatly amplified, since receiver gain is maximum without a signal, and is highly annoying. To overcome this problem, a circuit called the "noise-silencer", "squelch", "noise-suppressor," or "noise-limiter" is often used. This circuit cuts off the receiver output when no input signal is being received. This is accomplished by blocking either the detector or audio amplifier outputs when no signal is present. By blocking either one of these circuits, obviously no output will be amplified and fed to the speakers or earphones connected to the receiver output.

Automatic Frequency Control (AFC)

Automatic Frequency Control (AFC) is used to maintain a constant frequency separation between the received signal and the local oscillator signal, regardless of drift in either the local oscillator frequency or the received carrier frequency.

Figure 4-9 illustrates the basic components associated with an AFC circuit. A change in the frequency of the local oscillator will produce a change in the resultant IF. This change will be sensed by the "discriminator" circuit, a component used in AFC. The discriminator will produce a d.c. voltage which corresponds to the shift in frequency. The polarity of this d.c. voltage will be determined by the direction of the frequency shift (either positive or negative), while the amplitude of the d.c. voltage will be determined by the magnitude of the frequency shift (how far off frequency the shift is). This d.c. voltage is then fed to the "reactance" circuit. The reactance circuit controls the frequency determining circuit of the local oscillator. Working together, the discriminator and the reactance circuit correct any frequency deviation by the local oscillator or in the carrier and maintain the IF component of the processed signal in so doing.



76.98

Figure 4-9.—Automatic Frequency Control, "AFC", block diagram.

CHAPTER 5

BASIC ANTENNA THEORY

Operation of communication equipment over the entire range of the RF spectrum requires many types of antennas. At the communications center in which you work, you will need to know the basic types of antennas available to you operationally, their characteristics, and their uses. Very often, you, the operator, can mean the difference between efficient and inefficient communications. You will have a choice of many antennas and must select the one most suitable for the task at hand. Your operational training will acquaint you with the knowledge necessary to properly use the antennas at your disposal. However, your operational training WILL NOT acquaint you with the WHY of antennas, in other words, basic antenna theory. This chapter is intended to familiarize you with basic antenna terminology, definitions, and characteristics.

TERMS AND DEFINITIONS

The following terms and definitions are listed here to enhance your understanding of the material:

ANTENNA—A device used to radiate or receive radio waves.

ANTENNA TUNING—The process whereby an antenna is electrically "matched" to the output frequency of the transmitter.

BIDIRECTIONAL ANTENNA—An antenna that radiates or receives most of its energy in only two directions.

CHARACTERISTIC IMPEDANCE—That impedance of an antenna which, when the antenna is connected to the output of a transmission line, will show the voltage and current ratio to be the same at any given point along the antenna.

CURRENT "LOOP"—A point at which current is maximum along a transmission line or antenna.

CURRENT "NODE"—A point at which current is zero along a transmission line or antenna.

DIPOLE—An antenna approximately one-half wavelength long.

DIRECTIONAL ANTENNA—An antenna that radiates or receives radio waves more effectively in some directions than in others.

ELECTRIC FIELD—Electric "flux" lines that represent the direction in which the field is traveling.

END EFFECT—The effect of capacitance at the ends of an antenna.

FEED POINT—That point on an antenna to which a signal to be transmitted is delivered.

FIELD STRENGTH—The strength of an electric, magnetic, or electromagnetic field at a given point. (Also called field intensity).

HERTZ ANTENNA—An ungrounded half-wave antenna.

INCIDENT WAVE—An electromagnetic wave that is traveling from the transmitter in the direction of the antenna.

INSULATION RESISTANCE—The electrical resistance between two conductors that are separated by an insulating material. (Sometimes referred to as the "breakdown" resistance of a transmission line).

MAGNETIC FIELD—A space in which magnetic force, or magnetic "flux", is created by a moving electric field.

MARCONI ANTENNA—An antenna that is connected to ground at one end.

OMNIDIRECTIONAL ANTENNA—An antenna that radiates or receives equally well in all directions, except directly off the ends.

POLARIZATION—The direction of the electric field as radiated from a transmitting antenna.

RADIATION RESISTANCE—The total radiated power of an antenna divided by the square of the effective antenna current measured at the feed point.

REFLECTED WAVE—An electromagnetic wave that travels back toward the transmitter from the antenna due to a mismatch in impedance between the two.

RESONANCE—The condition that exists in an antenna circuit in which the inductive reactances balance out the capacitive reactances.

STANDING-WAVE RATIO (abbreviated SWR)—The ratio of maximum and minimum amplitudes of voltage, current, and field along a transmission line at a given frequency.

UNIDIRECTIONAL ANTENNA—An antenna that radiates only in one direction.

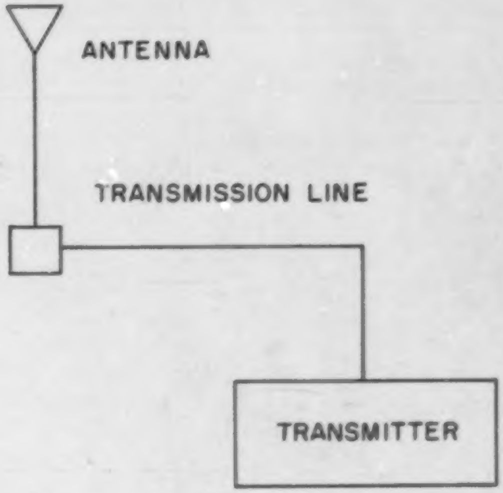
VOLTAGE "LOOP"—A point at which voltage is maximum.

VOLTAGE "NODE"—A point at which voltage is zero.

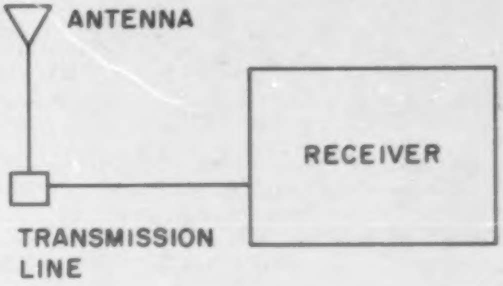
WAVELENGTH—The distance in feet or meters between points of corresponding phase of two consecutive cycles of a periodic wave.

BASIC ANTENNA CIRCUIT

We have defined an antenna as a device for transmitting or receiving radio waves. In effect, what we have said is that electrical energy from the transmitter is converted into electromagnetic energy by the antenna and radiated into space. On the reception end, electromagnetic energy is converted into electrical energy by the antenna and fed into the receiver. Figure 5-1 shows a basic transmitting circuit, and figure 5-2 shows a basic receiving circuit.



76.99
Figure 5-1.—Basic Transmitting Circuit.



76.100
Figure 5-2.—Basic Receiving Circuit.

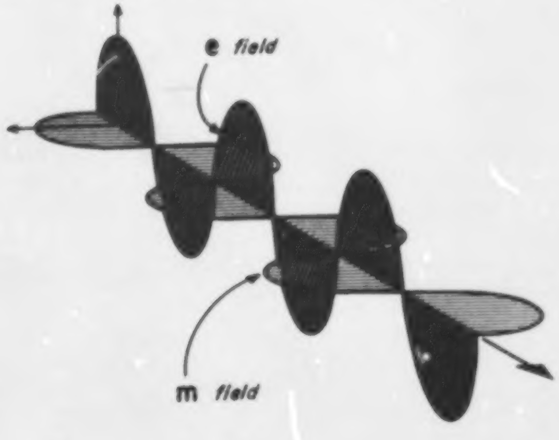
As shown in figure 5-1, the basic transmitting circuit is very simple. First, the transmitter is the source of electrical energy. From there the signal is delivered to a transmission line which serves to connect the transmitter and the antenna. The energy is delivered to the antenna via the transmission line and is radiated into space as an electromagnetic wave. Figure 5-2 simply reverses the process. The electromagnetic energy is intercepted by the receiving antenna, converted into electrical energy, fed to the transmission line, and is then fed to the input circuits of the receiver where it will be processed accordingly.

Before going further, let us take a look at the electromagnetic wave that is radiated by ANY antenna. Figure 5-3 shows an instantaneous cross-section of a radio wave that has been radiated. The wave itself is called ELECTROMAGNETIC because it is composed of both an electric and a magnetic field.

The principle involved here is that a moving electric field creates a magnetic field, and conversely, a moving magnetic field creates an electric field. These two fields, once created, are IN-PHASE with each other but are also PERPENDICULAR to each other. In other words, as the electric field rises in amplitude, so does the magnetic field. They reach a peak and drop to zero (dip) at the same time. Thus, they are in phase with each other. The electric field creates magnetic flux lines that extend out from it at a RIGHT ANGLE, as shown in figure 5-3. There magnetic flux lines are perpendicular to the electric field. Therefore, our moving field is called an electromagnetic field. The electric field is designated "e" and the magnetic field "m". The radiated electromagnetic wave travels through space at the speed of light. (The speed of light is 300,000,000 meters or about 186,000 miles per second).

ANTENNA CHARACTERISTICS

All antennas exhibit common characteristics. Sometimes, the most difficult subject concerning antennas is the terminology involved. In this section, we will discuss many of the misunderstood terms dealing with the theory of antennas.



93.12

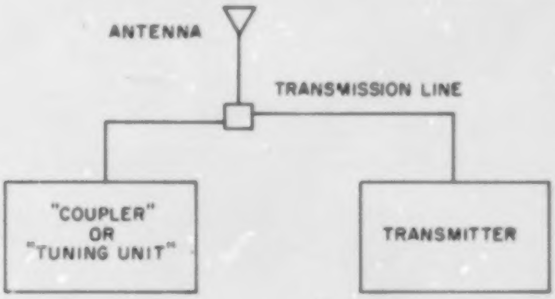
Figure 5-3.—Instantaneous cross-section of a radio wave.

Having a basic understanding of difficult-sounding terms will aid in your knowledge of all antennas as well as enhance your ability to better understand the antennas that you use daily at communication centers ashore or afloat.

Antenna Tuning

It is an accepted fact that for every frequency in the frequency spectrum there is an antenna that is perfect for radiating at that frequency. By this we mean that all of the power being transmitted from the transmitter to the antenna will be radiated into space. Unfortunately, this is the ideal and not the rule. Normally, some power is lost between the transmitter and the antenna. This power loss is due to the fact that the antenna is not of the perfect dimensions and size to radiate perfectly all of the power delivered to it from the transmitter. Naturally, it would be unrealistic to carry a separate antenna for every frequency that a communication center is capable of radiating; it would require that a ship have millions of antennas onboard, and that would be impossible.

To overcome this, we have a means whereby we can electrically lengthen and shorten antennas to better match the frequency which we want to transmit. This process is known as "antenna tuning". In figure 5-1, we showed a basic antenna circuit. In figure 5-4, we show the same circuit, but with the addition of what is normally referred to as an antenna "coupler", or "tuning unit". This coupler is electrically



76.101

Figure 5-4.—Coupler is connected to antenna to "tune" the antenna.

connected to the antenna and is used to adjust the apparent physical length of the antenna by electrical means. This simply means that the antenna does not physically change length as such; the antenna is electrically adapted to the output frequency of the transmitter and "appears" to change its physical length.

The antenna coupler, or tuning unit, is normally connected to the antenna with a different cable than that of the transmitter. In other words, one cable is connected from the transmitter to the antenna, and a different one is connected between the coupler and the antenna. The cable connected between the transmitter and the antenna is called the "RF cable". This cable carries the RF signal from the transmitter to the antenna so that the signal will be radiated into the atmosphere. The other cable is called the "control cable". It carries the signals from the coupler unit that serve to "tune" the antenna. Once the antenna is properly tuned to the operating frequency signal which it must radiate into the atmosphere, the antenna is said to be "RESONANT". In other words, it is matched to the operating frequency.

Another term used in antenna tuning is "STANDING-WAVE RATIO", abbreviated SWR. Although we have defined this term earlier in this chapter, a generally accepted definition would be the relative "degree of resonance" achieved with antenna tuning. It is not necessary at this point to understand the complexities of current and voltage along an antenna that determine the exact SWR, but it is important to understand the SWR when the ratio is expressed numerically.

Most antenna coupling units have front panel meters that read the relative SWR achieved via antenna tuning. You will hear SWR expressed numerically in nearly every tuning procedure. You will hear terms such as "four-to-one", or "two-to-one", or "three-to-one", as examples. You will see them written 4:1 SWR, or 2:1 SWR, or 3:1 SWR. The important thing to know about these figures is that the LOWER the number ratio is, the BETTER is the standing-wave ratio. The better the SWR, the better is the match between the antenna and the transmitter for transmission of the RF signal. For example, a 2:1 SWR is better than a 3:1 SWR, and a 4:1 SWR is better than a 5:1 SWR. Of course, a 1:1 SWR is perfect. This would mean that the antenna is perfectly matched to the frequency to be transmitted from the transmitter. This is nearly impossible, of course, because there will always be some power loss between the transmitter and the antenna due to the natural impedances that exist between the two. When tuning, you try to minimize the impedances between the transmitter and the antenna and, therefore, improve the standing-wave ratio between the two. As you approach resonance, you will notice your SWR figure on front panel meters begin to drop to a lower numerical value. A "good" SWR is considered to be 4 or below. For example, 4:1, 3:1, or 2:1. Anything over 4, such as 5:1, 6:1, 9:1, etc., is considered "bad".

Antenna Feed Point

The term "feed point" indicates the point at which the RF cable that carries the signal from the transmitter is connected to the antenna. The type of antenna being used and the desired operating characteristics determine the feed point. If the RF transmission line is connected to the base of an antenna, the antenna is said to be END-FED. If the RF transmission is connected at the center of an antenna, the antenna is said to be MID-FED or CENTER-FED.

Characteristic Impedance

Everything exhibits some amount of impedance. Even a straight piece of copper wire 3 inches long will offer some resistance to current flow, however small. The characteristic impedance of this same piece of copper wire is considered to be its overall resistance offered to a signal. The transmission line between an antenna and a transmitter has a certain amount of characteristic impedance. The antenna also has a certain amount of characteristic impedance. It is the basic mismatch in impedances between the transmitter and the antenna that makes antenna tuning necessary. Naturally, as transmitters, transmission lines, and antennas become more complex and contain more complex circuits and components, the necessity for tuning becomes more critical.

In an ideal situation, the transmission line matches the output impedance of the transmitter and the input impedance of the antenna. If this were the case, there would be no need to tune an antenna because there would be no resistance to the signal frequency to be transmitted. Unfortunately, this is rarely, if ever, the case.

Listed in every antenna technical manual is the "characteristic impedance" of the antenna. You will normally find this to be 36 ohms, 52 ohms, or 70 ohms. Most communications antennas are designed to offer this resistance at resonance, with the most standard being 52 ohms. At resonance, the antenna should appear electrically as a large resistor offering 52 ohms of resistance at the signal frequency. The objective of antenna tuning is to electrically tune out the various impedances and to "match" the antenna's length to the frequency being radiated AT THE CHARACTERISTIC IMPEDANCE THAT THE ANTENNA WAS DESIGNED FOR. If we were to achieve a standing-wave ratio of 1:1, it would mean that we have succeeded in tuning out all other impedances, and the antenna now offers its characteristic impedance. A 1:1 SWR is rarely achieved, of course, but the object is to get as nearly as possible to it in order to have only the characteristic impedance of the antenna remaining. Now let us see how the frequency of the signal to be transmitted affects tuning.

Frequency And Impedance

In chapter 2, you learned that inductive reactance (X_L) is actually resistance and is measured in ohms. In the same chapter, you learned that capacitive reactance (X_C) is also measured in ohms. You learned that inductive reactance is caused by the effect that a.c. has on coils. It was found that any two points of different electrical potential exhibit capacitance and that capacitive reactance is the reaction of capacitance to an a.c. signal. What is frequency? Frequency is the number of times that an a.c. signal makes a complete cycle in one second. As we increase or decrease frequency, the inductive and capacitive reactances will alternately increase and decrease as well. These reactances exist between conductors in the transmission line, between coils of helical antennas, and between components physically located inside antennas themselves. Some antennas are no more than straight pieces of metal, while others are very complex and contain electronic circuits and components inside the shell of the antenna itself. Whenever a signal at a certain frequency is applied to the antenna via the transmission line, all of the parts and components that exist between the transmitter and the antenna and inside the antenna will begin to electrically "react" to that signal frequency, offering impedance to the signal frequency. These various inductive and capacitive reactances are what we are attempting to "tune out" via the coupler unit in order to present the characteristic impedance, or as close as possible to it, to the signal frequency.

How do reactances vary with frequency? We can refer to the basic reactance formulas to find this out. The formula for capacitive reactance is:

$$X_C = \frac{1}{2\text{pi } F\ C}$$

where: 2pi = 6.28 (3.14 x 2)

F = frequency in hertz

C = capacitance in farads

Since capacitive reactance is inversely proportional to frequency, we find that as we increase frequency, we decrease X_C.

The formula for inductive reactance (X_L) is:

$X_L = 2\text{pi } F\ L$

where: 2pi = 6.28 (3.14 x 2)

F = frequency in hertz

L = inductance in henrys

Since inductive reactance is directly proportional to frequency, we find that as we increase frequency, we increase X_L.

Since these reactances are effectively resistances and measured in ohms, they are effectively added to the characteristic impedance of the antenna and will change anytime we change frequency. Hence, it is necessary for antenna tuning to achieve characteristic impedance, or close to it. Remember, the only variable in the reactances is frequency.

Wavelength

Whenever RF current flows through a transmitting antenna, electromagnetic (radio) waves are radiated from the antenna in all directions. These waves travel at approximately the speed of light. The frequency of the radio wave that is radiated by the antenna will be equal to the frequency of the RF current.

The velocity of a radio wave remains the same regardless of frequency. This is important to remember in computations that concern antenna length. Whenever the length of an antenna is referred to, the term WAVELENGTH is used. You will hear antennas referred to as "half-wave", "quarter-wave", or "full-wave". These terms describe the relative length of an antenna, whether it be electrical or physical.

Simply stated, the definition of wavelength is "the distance traveled by the radio wave in the time required for one cycle". This means that wavelength will vary with frequency. If we increase the frequency, the time required to complete one cycle of a.c. is naturally less. Therefore, the wavelength is less. If we decrease the frequency, the time required to complete one cycle of a.c. is longer. Therefore, the wavelength is more, or longer. Another word for wavelength is LAMBDA, designated by the symbol, λ.

As previously mentioned, when tuning an antenna, we are electrically lengthening or shortening the antenna to achieve resonance at that frequency. In doing so, we are actually changing the wavelength of the antenna. The wavelength of an antenna can be computed quite simply. It is known that a radio wave travels at a constant speed of 300,000,000 meters (or 186,000 miles) per second. From this constant speed, the length of 1 cycle (wavelength) can be found by dividing velocity of the wave by its frequency. Expressed as a formula:

$$\text{Wavelength in meters} = \frac{300{,}000{,}000}{\text{Frequency in hertz}}$$

Because there are 3.28 feet in 1 meter, we can also compute wavelength in feet. Multiplying 3.28 times 300,000,000 equals 984,000,000 feet. Therefore:

$$\text{Wavelength in feet} = \frac{984{,}000{,}000}{\text{Frequency in hertz}}$$

It should be noted that these specific formulas are only applicable where frequency in hertz is used. When the frequency is expressed in values other than hertz (kHz or MHz), the constant must be converted to the corresponding value, (300,000 or 984,000 for kHz and 300 or 984 for MHz).

The electrical length of an antenna is not necessarily the same as its actual physical length. Radiofrequency energy travels at the speed of light in free space. However, RF energy on an antenna moves at a speed considerably less than that in free space. Because of the difference in velocity, the physical length no longer corresponds to the electrical length of an antenna. Thus, an antenna may be called a half-wave antenna electrically, but it is physically somewhat shorter.

If an antenna were made of very thin wire and isolated perfectly in space, its electrical length would correspond closely to its physical length. However, the antenna is never isolated completely from surrounding objects. The circumference of the wire itself; the capacitance introduced by insulators; and the capacitance introduced by the conductors in the transmission line and adjacent bulkheads, stacks, and masts all combine to change the velocity of the wave in the antenna. This change is called "END EFFECT" because the ends of the antenna are made farther apart electrically than they are physically. Consequently, the physical length of an antenna will be approximately 5 percent shorter than the corresponding wavelength in space. For example, to compute the electrical length in feet of an antenna that is transmitting a signal at 1 MHz:

$$\frac{984 \text{ (velocity)}}{1 \text{ (frequency)}} = 984 \text{ feet (electrical length)}$$

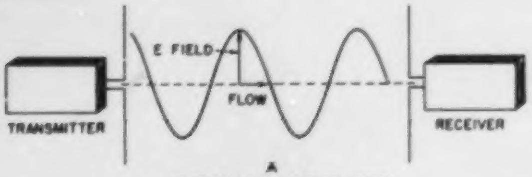
To find the corresponding physical length, we would multiply the electrical length times 95%:

$984 \times 95\% = 935$ feet (physical length).

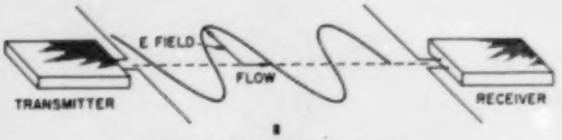
It should be understood that these computations are for finding the electrical and physical lengths of a FULL-WAVE antenna. If we wanted to compute the lengths of a half-wave antenna, we would simply divide the result by 2. For a quarter-wave antenna, we would divide the result by 4.

Wave Polarization

The position of an antenna in space determines the polarization of the emitted radio wave. Thus, an antenna that is vertical with respect to the earth radiates a vertically polarized radio wave, while a horizontally positioned antenna radiates a horizontally polarized wave. Figure 5-5 shows a vertically and a horizontally polarized wave. Note that the electric field corresponds to



A
VERTICALLY POLARIZED WAVE



B
HORIZONTALLY POLARIZED WAVE

13.32
Figure 5-5.—Vertically and Horizontally polarized waves.

the polarization of the wave. Whenever the antenna is vertically polarized, the electric field will also be vertical, and vice-versa for horizontal polarization.

At lower frequencies, wave polarization will remain fairly constant as it travels through space. At higher frequencies, however, the polarization usually varies, sometimes quite rapidly, because the wavefront splits into several components which follow different paths.

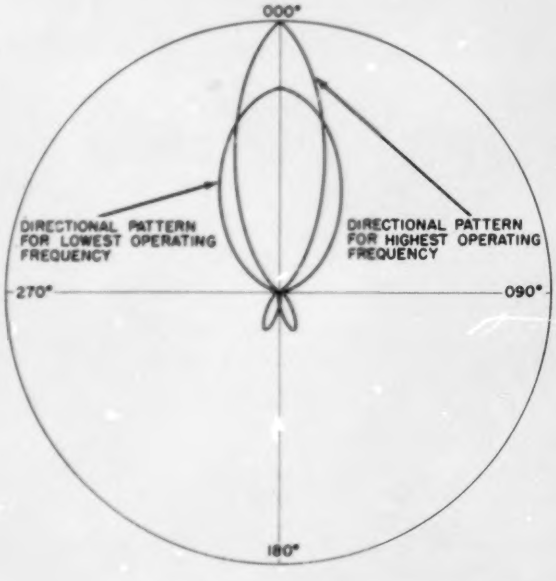
When antennas are close to the ground, vertically polarized radio waves yield a stronger signal close to the earth than do horizontally polarized waves. When the transmitting and receiving antennas are at least 1 wavelength above ground, the two types of polarization are approximately the same in field intensity near the surface of the earth. When the transmitting antenna is several wavelengths above the ground, horizontally polarized waves result in a stronger signal close to the earth than is possible with vertical polarization.

Polarization of a radio wave is a major consideration in efficient transmission and reception of radio signals. Thus, if a single-wire antenna is used to extract energy from a passing radio wave, maximum signal pick-up results when the antenna is so placed physically that it lies in the same direction as the electric field component. For this reason, a vertical antenna should be used for efficient reception of vertically polarized waves. A horizontal antenna should be used for reception of horizontally polarized waves.

Directivity

All antennas are directive to some extent. In general, however, the term "directional antenna" refers to an antenna that has been deliberately designed to concentrate its radiation in a relatively narrow beam. The directivity of an antenna refers to the sharpness or narrowness of its radiation pattern. An antenna with a sharp pattern in the horizontal plane has good "horizontal directivity". An antenna with a sharp pattern in the vertical plane has good "vertical directivity". Antennas that have directivity for transmitting exhibit similar directivity when used for receiving.

The directional characteristics of an antenna are determined to a great extent by its design and the position in which it is installed. Thus, certain directional qualities are associated with each type of antenna. The directivity of an antenna can be determined by its "RADIATION PATTERN". (See figure 5-6.) In figure 5-6, the rounded projections of the pattern are called LOBES and the indented portions, representing minimum energy pick-up, are called NULLS. The information contained in the antenna radiation pattern can be used to determine the best operational use for the antenna. As


000°
DIRECTIONAL PATTERN FOR LOWEST OPERATING FREQUENCY
DIRECTIONAL PATTERN FOR HIGHEST OPERATING FREQUENCY
270°
090°
180°

13.33
Figure 5-6.—RADIATION PATTERN of an antenna.

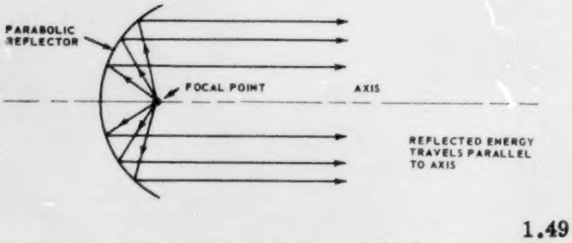
can be seen, at the lowest operating frequency of the antenna, the pattern is more rounded and less directional than the pattern at the highest operating frequency. The width of these directive lobes is often referred to as the antenna's "BEAMWIDTH".

Beamwidth, of course, varies depending upon the type of antenna used. In general, we use three terms to describe the type of directional qualities associated with an antenna: OMNIDIRECTIONAL, BIDIRECTIONAL, and UNIDIRECTIONAL. Omnidirectional antennas radiate and receive equally well in all directions, except off of the ends. Bidirectional antennas radiate or receive efficiently in only two directions, for example North and South or East and West. Unidirectional antennas radiate or receive efficiently in one direction only.

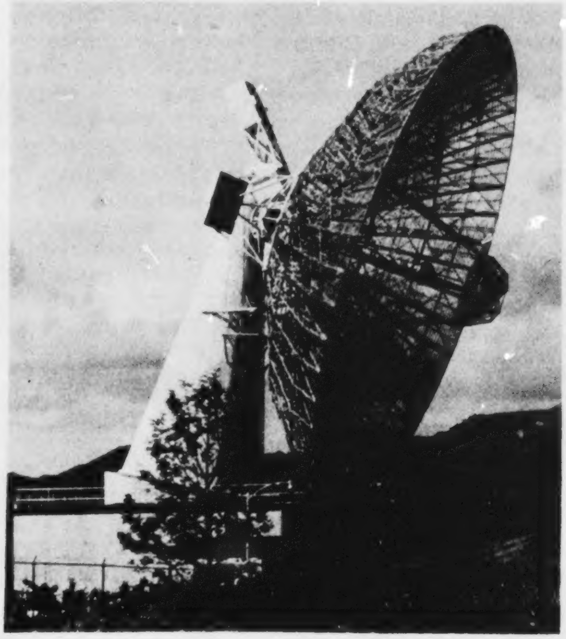
Most antennas are either omnidirectional or unidirectional. Bidirectional antennas are rarely used in naval communications. Examples of an omnidirectional antenna are the antennas used to transmit fleet broadcasts or most medium-to-high frequency antennas used aboard ship. An example of a unidirectional antenna is a parabolic, or "dish", antenna shown in figure 5-7. As shown in figure 5-7, an antenna (normally a half-wave) is placed at the "focal" point and radiates the signal back into a large reflecting surface (called the dish). The effect is to transmit a very narrow beam of energy that is essentially unidirectional. Figure 5-8 is a picture of a large, unidirectional parabolic antenna.

Field Intensity

Field intensity, or field strength as it is sometimes called, is the effective value of the electric field intensity measured at a particular point from the transmitting antenna. It is very seldom that the operational characteristics of an antenna are as the technical manual states. In order to determine the exact operating characteristics of an antenna, various measurements and tests are made after an antenna is installed and is being test operated. Often, on the basis of these measurements, changes are made in the design or installation of the antenna to improve the radiation pattern.



1.49
Figure 5-7.—Parabolic, or "Dish" antenna.



31.61
Figure 5-8.—Unidirectional Parabolic.

It is very important to know the direction and intensity of the power being radiated from an antenna. To determine these values, measurements of the field intensity are made at various distances from and around the antenna.

In order to determine the field strength or field intensity, it is desirable that some type of standard antenna be used as the basis for all comparisons. The generally accepted antenna for this is a standard wire antenna exactly 1 meter long. The magnitude of the signal voltage (in microvolts) induced into this antenna is called the ABSOLUTE FIELD STRENGTH and is measured in MICROVOLTS PER METER.

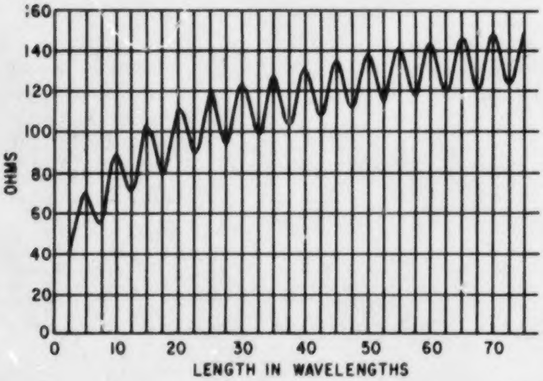
The antenna picks up the induced radio wave and feeds the induced voltage to a sensitive receiver. An indicating voltmeter is connected at the output of the receiver. This voltmeter indicates the absolute value of the field strength in microvolts per meter. The antenna being tested and the standard antenna being used as a reference should both be polarized in the same direction.

Absolute field intensity measurements are not difficult to make. However, the necessary equipment is relatively complex, bulky, and must be pre-set and adjusted very carefully. Often, all that is necessary to know is relative field strength. Simple field strength meters and a pick-up antenna are all that is necessary to make the measurements. Again, the pick-up antenna (the antenna that is being used for reference) should be polarized the same as the antenna under test.

Radiation Resistance

An antenna at the end of the transmission line is equivalent to a resistance that absorbs a certain amount of energy from the transmitter. This is the energy that is radiated into space, discounting natural losses that occur in the antenna. The value of resistance that would dissipate the same power that the antenna dissipates is called the RADIATION RESISTANCE. The power that is dissipated in a resistor is equal to I^2R. Similarly, the power that is dissipated in (radiated from) an antenna is equal to the current at the feed point (squared) times the radiation resistance of the antenna.

Naturally, as we tune an antenna and effectively lengthen and shorten it, we are varying the amount of resistance offered to a given signal. Therefore, the radiation resistance of an antenna varies as we vary the frequency of the transmitter and tune the antenna. Figure 5-9 shows how the radiation resistance varies with antenna length for an antenna ideally located in free space. The radiation resistance is never perfectly proportional to antenna length because of the effects of the antenna height above the ground and its proximity to nearby objects.



20.247

Figure 5-9.—How radiation resistance varies with antenna length.

Incident and Reflected Waves

Whenever we energize or "feed" an antenna with an a.c. signal, waves of energy are created along the length of the antenna. These waves travel toward the end of the antenna. The waves coming from the transmitter toward the end of the antenna are called the INCIDENT WAVES.

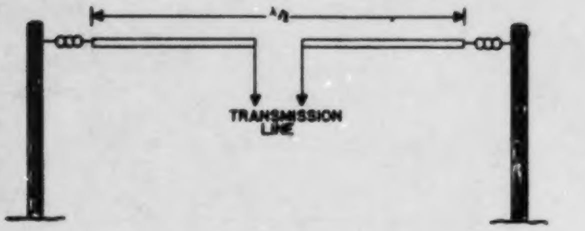
As the incident wave travels toward the end of the antenna, the large resistance offered by the "open-circuit" at the end of the antenna forces the energy back towards the feed point. This energy is essentially "reflected" back and is called the REFLECTED WAVE.

If the antenna is resonant to the frequency being supplied by the transmitter, the reflected waves and the incident waves are in phase along the length of the antenna and tend to reinforce each other. It is at this point that radiation is maximum, and the standing-wave ratio (SWR) is best. Whenever the antenna is not resonant at the frequency being supplied by the transmitter, the incident and reflected waves are out of phase along the length of the antenna and tend to cancel each other out. These cancellations are called "power losses" (I^2R losses) suffered whenever the SWR is very poor, such as 6:1 or 5:1, etc.

HALF-WAVE THEORY

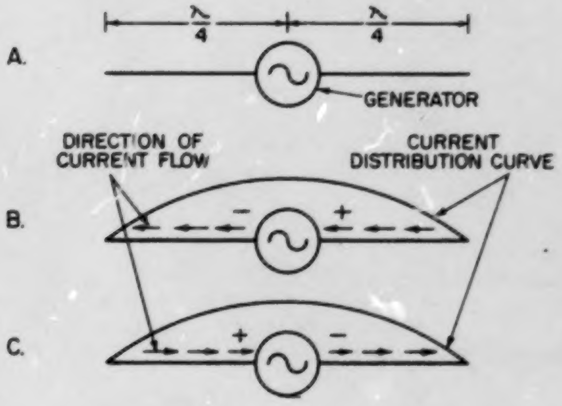
Whenever an antenna is resonant at a particular frequency, the electric charge is permitted to travel from one end of the antenna to the other, and back again, in the time of 1 cycle. Because the charge must travel the length of the antenna twice, the length of antenna needed to have the charge travel 1 wavelength in 1 cycle is one-half of a wavelength long. Thus, the half-wave antenna is the shortest resonant length that can be used.

The basic half-wave antenna is commonly called a dipole, doublet, or Hertz antenna. This type of antenna will not function properly and efficiently unless its length is one-half wavelength of the frequency to be radiated. Figure 5-10 shows a theoretical half-wave antenna with its feed point at the center of the antenna. Both sections of the antenna on each side of the feed point are $\lambda/4$ (1/4 wavelength) at the



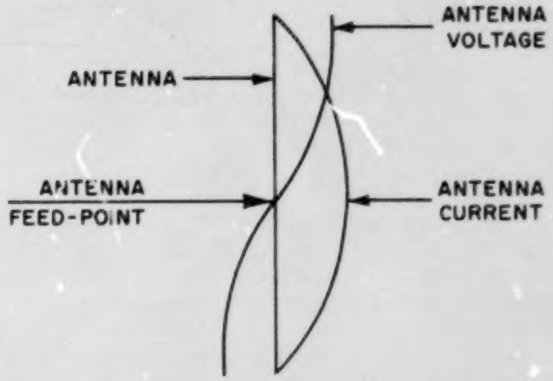
13.34

Figure 5-10.—Half-wave antenna with the feed point at the center.



20.242

Figure 5-11.—AC on an antenna.



76.202

Figure 5-12.—Current and Voltage on a Mid-fed half-wave.

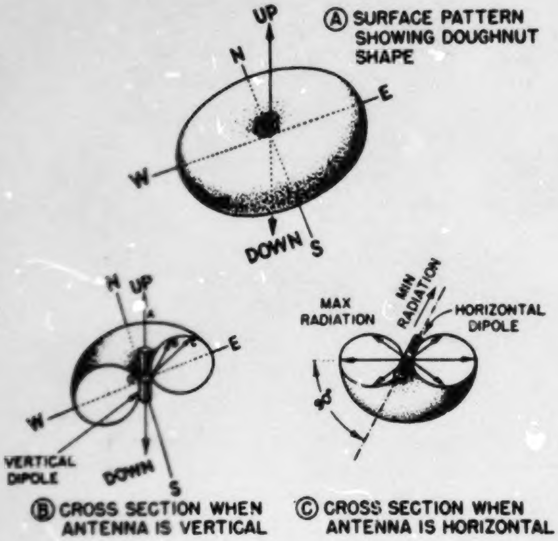
operating frequency. Together, of course, the effective length of the antenna is λ/2 (1/2 wavelength) at the operating frequency. One of the features of the dipole is that it need not be connected to ground. The reason for this is that antennas of shorter than a half wavelength must use ground to achieve half-wave characteristics; whereas, the half-wave antenna is already long enough to properly radiate the transmitted signal.

At low frequencies, half-wave antennas are rather long. Therefore, they are used primarily at shore stations where there is sufficient room. It should be pointed out, however, that due to more sophisticated antenna systems and tuning processes, half-wave antennas can be electrically achieved onboard ship, and that wavelength is becoming less and less the criteria for determining the types of antennas to be used on ships. Dipole antennas may be mounted horizontally or vertically depending upon the desired polarization and may be fed at the center or at the ends. The dipole antenna may be installed far above other energy-absorbing structures because it is ungrounded.

An important point to remember is that a transmitter is no more than a source of a.c. Thus, if we connect a transmitter to the electrical center of a dipole via a transmission line, the antenna will react as though an a.c. generator were set between two quarter-wavelength antennas. Figure 5-11 shows the disposition of this alternating current. During one-half of the alternating cycle, current flows in the antenna from right to left (figure 5-11, view B). During the next half cycle, current flows in the opposite direction (figure 5-11, view C).

In a half-wave antenna, the current is maximum at the center and zero at the ends (figure 5-12); whereas, the voltage is maximum at the ends and minimum at the center. Therefore, the impedance varies along the antenna, being minimum at the center and increasing toward the ends. If energy is fed to a half-wave antenna at its center, it is said to be CENTER FED (current fed); if energy is fed to a half-wave antenna at either of the ends, it is said to be END FED (voltage fed).

The field radiated by a dipole is the shape of a doughnut (figure 5-13). Part A of figure 5-13 shows the radiating pattern of a dipole. Part B of figure 5-13 shows a cross-section of the radiated wave for a vertically polarized dipole. Part C of figure 5-13 is a cross-section of a horizontally polarized dipole. Notice that maximum radiation takes place in a plane that is


UP
Ⓐ SURFACE PATTERN SHOWING DOUGHNUT SHAPE
N
E
W
DOWN
S
N
UP
E
W
VERTICAL DIPOLE
DOWN
S
MAX RADIATION
MIN RADIATION
HORIZONTAL DIPOLE
90°
Ⓑ CROSS SECTION WHEN ANTENNA IS VERTICAL
Ⓒ CROSS SECTION WHEN ANTENNA IS HORIZONTAL

1.255

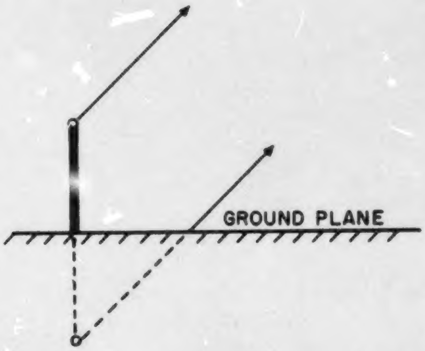
Figure 5-13.—Radiation pattern of a dipole.

perpendicular to the axis of the antenna. Minimum radiation is off the ends of a dipole.

QUARTER-WAVE THEORY

As was previously explained, a half-wave antenna is the shortest practical length that may be effectively used for the radiation of radio signals. The natural question, then, is: "How do we use a quarter-wavelength antenna if a half-wavelength is the shortest that can be used?" The answer to that is basically simple.

First of all, the total radiation from an antenna is made up of two components. One component is that part of the radiated signal which leaves the antenna directly, and the other is a GROUND REFLECTION that appears to come from an underground image of the real antenna, as shown in figure 5-14. This image is also sometimes called the MIRROR IMAGE and is considered to be as far below the ground as the real antenna is above it. The antenna need not be placed at the surface of the earth to produce an image. This image is sometimes achieved by placing an antenna next to, or above, a large metallic ground. In other words, instead of using the earth to reflect the other half of the desired image, we can use a very good metallic surface as "ground".

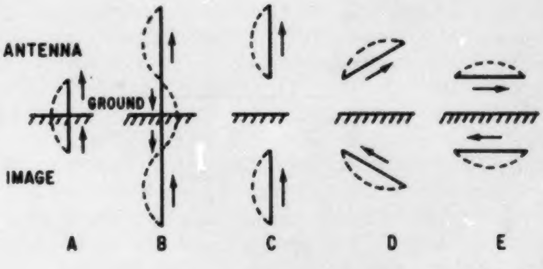


76.103

Figure 5-14.—Direct and "image" signal.

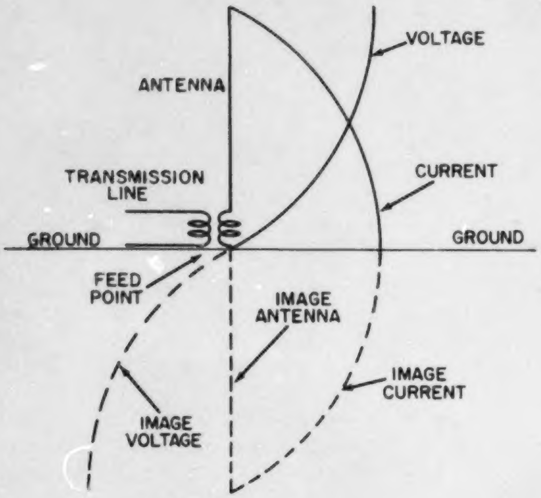
Figure 5-15 shows basic current distribution in a real and image antenna. There are certain directions in which the direct wave from the real antenna and the reflected wave from the image are exactly equal in amplitude but opposite in phase. Conversely, there are other directions in which the direct and reflected waves are equal in amplitude and in phase. Thus, depending on the direction and location of the point at which the field strength could be measured, the resultant field strength may be (1) twice the field strength from the real antenna alone, (2) zero field strength, or (3) some intermediate value between maximum and minimum. It is this "real" and "image" radiated field that forms the basis for using quarter-wavelength antennas.

A grounded antenna which is one-fourth wavelength of the frequency to be transmitted or received is known as a quarter-wave antenna, and is sometimes referred to as a MARCONI antenna. Figure 5-16 shows typical current and voltage distribution on a quarter-wave antenna. Notice that it is very similar to the half-wave antenna in this respect. Although the antenna itself is only a quarter-wavelength, the earth acts as another quarter-wavelength to produce the



76.104

Figure 5-15.—Current distribution in a real and image antenna.

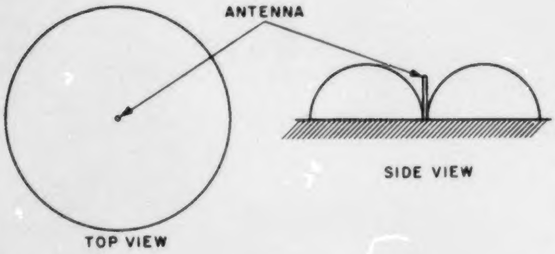

VOLTAGE
ANTENNA
TRANSMISSION LINE
CURRENT
GROUND
GROUND
FEED POINT
IMAGE ANTENNA
IMAGE CURRENT
IMAGE VOLTAGE

13.35

Figure 5-16.—Typical current and voltage distribution on a quarter-wave antenna.

"image" and achieve the desired half-wave characteristics.

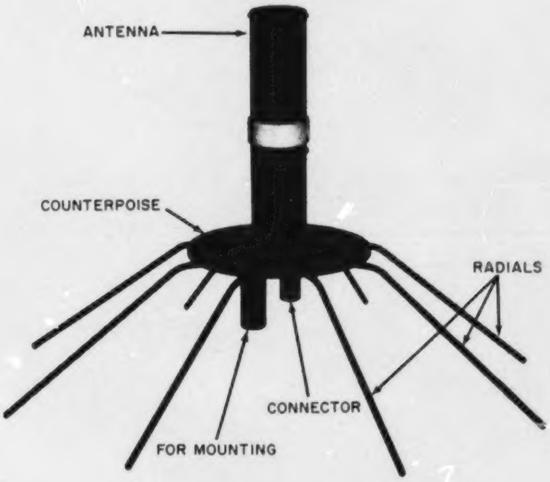
This reflected-energy principle is very useful in the lower frequency ranges, although ground reflections occur in the high frequency range as well. Figure 5-17 shows the radiation pattern produced by a grounded quarter-wave antenna at a shore transmitting site. Notice that the top view shows an omnidirectional radiation pattern but that the side view shows essentially half of the necessary signal for proper radiation. The remaining half of the signal is obtained via ground reflection.


ANTENNA
TOP VIEW
SIDE VIEW

76.12

Figure 5-17.—Radiation pattern for grounded, quarter-wave antenna ashore.

Another method of achieving reflected images is through the use of "ground planes". Basically, what this means is that a large reflecting metallic surface is used as a substitute for "ground" or "earth". This method is frequently used in the VHF/UHF frequency ranges. Figure 5-18 shows a commonly used UHF antenna (AS-390/SRC) which utilizes this principle. The ground plane is also sometimes referred to as a "COUNTERPOISE", as is shown here in figure 5-18. Together, the counterpoise and the radials comprise the reflecting surface which, in turn, provide the necessary reflected image.


ANTENNA
COUNTERPOISE
RADIALS
CONNECTOR
FOR MOUNTING

25.220

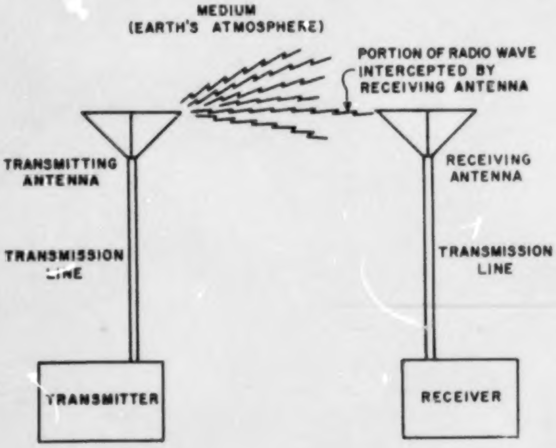
Figure 5-18.—Common UHF antenna utilizing "counterpoise", or ground plane.

CHAPTER 6

RADIO WAVE PROPAGATION

The transmission of radio waves through space is known as WAVE PROPAGATION. An electromagnetic wave must be propagated through space to a receiving antenna to establish a useful communications system. In any radio communications system, energy in the form of electromagnetic waves is generated by the transmitter and fed to an antenna by means of a transmission line. The antenna radiates this energy out into space at the speed of light. Receiving antennas, placed in the path of the traveling radio wave, absorb part of the radiated energy and send it through a transmission line to a receiver. Figure 6-1 shows an example of a simple radio communication network.

Successful communication by means of radio waves depends on the power of the transmitter, the frequency used, the distance between the transmitter and receiver, and the sensitivity of the receiver. The ability of the earth's atmosphere to conduct energy to its destination, together with the nature of the terrain between the sending and receiving points, may be responsible for the frequency used to transmit the radio signal. Interferring signals can make reception impossible at a desired time. Also, the amount of noise present at the signal frequency and transmission line losses may combine to make unintelligible an otherwise good signal.



31.6

Figure 6-1.—Simple Radio Communication Network.

Depending upon the frequency used, the primary medium for transmission may be the surface of the earth or the free space surrounding the earth, (normally both). By far the more complex of these two mediums is free space. Therefore, it is necessary that the nature of free space be known so that its effects on the quality of transmission may be predicted. Weather conditions, changes in the level of radiation from the sun, and physical obstructions on the earth's surface all affect the quality and reliability of transmission. Because we cannot control the phenomena existing in the propagating mediums, our knowledge of them is of primary importance to achieve successful communications.

TERMS AND DEFINITIONS

In our discussion of radio wave propagation, a number of terms are used that could tend to confuse you, if the terms are not understood. Therefore, the following list of defined terms is provided for your reference.

ATMOSPHERE—The mass of space surrounding the earth, including the troposphere, stratosphere, and ionosphere. Also called "free space".

ATTENUATION—The decrease in signal strength of a radio wave.

CONDUCTIVITY—A measure of the ability of a material to act as a path for electron flow. (Measured in mhos per meter).

CRITICAL FREQUENCY—That frequency below which an electromagnetic wave is bent back to earth by a layer in the ionosphere.

DIFFRACTION—The bending of an electromagnetic wave around the edge(s) of a solid object.

DIRECT WAVE—A radio wave that is propagated in a straight line through space from the transmitting to the receiving antennas.

DISTORTION—An undesired change in an electromagnetic waveform.

FADING—The variation of radio signal strength, usually gradual, during the time of reception.

GIGAHERTZ (GHz)—An expression denoting 1000 MHz.

GROUND WAVE—A radio wave that travels (propagates) close to the earth's surface and reaches the receiving antenna without being influenced by the ionosphere. The ground wave includes all components of a radio wave traveling over the earth except the sky (ionospheric) wave.

HERTZ (Hz)—Cycles per second.

INCIDENT WAVES—A term denoting that portion of a radio wave passing from one medium into another which will result in that wave being reflected, refracted, diffracted, or scattered.

IONOSPHERE—That part of the earth's outer atmosphere where ionization is present in sufficient quantity to affect the propagation of radio waves. Also known as that portion of the atmosphere above the stratosphere.

MAXIMUM USABLE FREQUENCY (MUF)—The highest frequency or frequencies that may be used at a specified time of day for radio communications between two points.

NOISE—Any extraneous electrical disturbance tending to interfere with the normal reception of a transmitted signal.

FREQUENCY OF OPTIMUM TRANSMISSION (FOT)—The most reliable frequency for propagation at a specific time.

LOWEST USABLE FREQUENCY (LUF)—The lowest frequency that may be used during a specific time, depending upon power and bandwidth requirements.

PROPAGATION—The transmission of electromagnetic (radio) waves from one point to another.

REFLECTION—The phenomenon occurring when a radio wave strikes the surface of the earth at some distance from the antenna and is returned upward toward the ionized layer of air.

REFRACTION—The phenomenon occurring when a radio wave obliquely passes from one medium to another of different density, causing the wave to change direction.

SPACE WAVE—Sometimes called the tropospheric wave. A radio wave that travels entirely through the earth's troposphere.

SKY WAVE—A radio wave that is propagated or acted upon by the ionosphere.

SUNSPOT NUMBERS—The number of dark, irregularly shaped areas on the surface of the sun caused by violent solar eruptions. Counted and averaged over a period of time, they are used to predict the average sunspot activity. The average of these numbers is called "smooth sunspot numbers".

SURFACE WAVE—That part of the groundwave that is affected chiefly by the conductivity of the earth.

STRATOSPHERE—That part of the earth's atmosphere lying between the troposphere and the ionosphere.

TROPOSPHERE—The lower part of the earth's atmosphere, lying between the surface of the earth and the stratosphere.

DIFFRACTION, REFLECTION, AND REFRACTION

One of the many problems encountered in the propagation of radio waves is the changeable conditions of the transmission path through the various mediums. As a radio wave is traveling through space, it can be affected adversely or in such a manner as to enhance communications. It may change direction, velocity, or be completely absorbed within the propagating medium.

The atmosphere of the earth is the common medium for propagation and a study of radio propagation is concerned chiefly with properties and effects of this medium. Radio waves travel in two ways from a transmitter to a receiver: by means of GROUND WAVES, which travel close to the surface of the earth or by SKY WAVES, which travel up to electrically conducting regions of the earth's atmosphere and are returned to earth, (see figure 6-2). Some forms of transmission are combinations of both ground waves and sky waves.

Like other forms of electromagnetic radiation, radio waves can be diffracted, reflected, and refracted. Ground waves are affected partially by the curvature and electrical characteristics of the earth. Sky waves are affected in varying degrees by the constant changes taking place in the upper atmosphere.

Diffraction

A radio wave is bent when it passes the edge of an object. If a beam of light shines on the edge of an opaque screen in a room, it can be observed that the screen does not cast a perfectly outlined shadow. The edges of the shadow are not outlined sharply because the light rays are bent around the edge of the screen which decreases the area of total shadow. The bending, called DIFFRACTION, results in a change of direction of part of the energy from the line-of-sight path.

Figure 6-3 shows the diffraction of waves around a solid object. The lower the frequency of the wave, or the longer the wavelength, the greater the bending of the wave. Thus, sound waves are diffracted more than radio waves. Diffraction aids in explaining why radio waves of proper frequency can be received on the far side of a mountain or down in a valley and why sound waves can readily be heard around the corner of a building. In the propagation of radio waves at a distance, diffraction is a significant consideration because the largest object to be contended with is the bulge of the earth itself, which prevents a direct passage of the wave from the transmitter to the receiver. By using high power and very low frequencies, the waves of a transmitted signal can be made to encircle the earth by diffraction.

Reflection

Radio waves may be reflected from any sharply defined substances or objects of suitable characteristics and dimensions which are

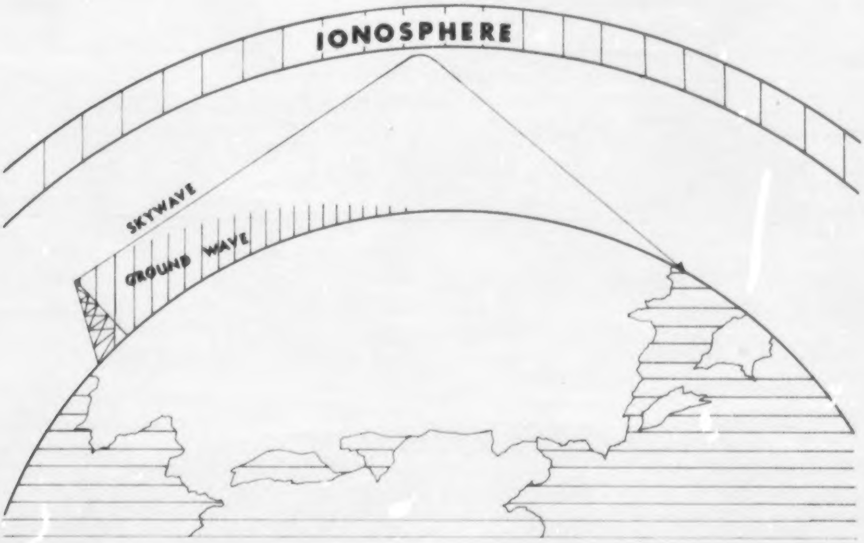
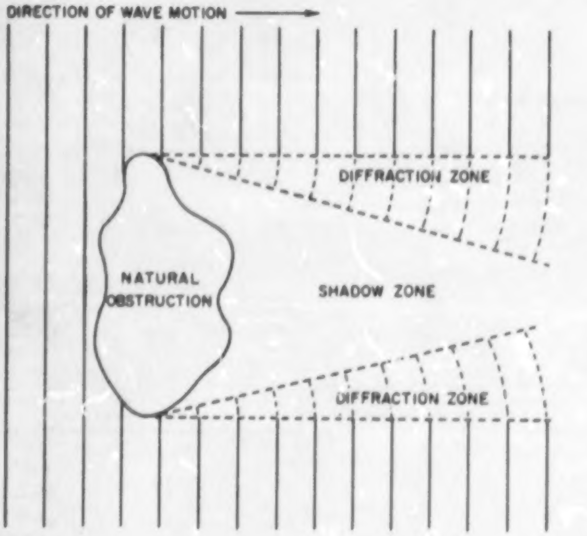


Figure 6-2.—Groundwaves and Skywaves.

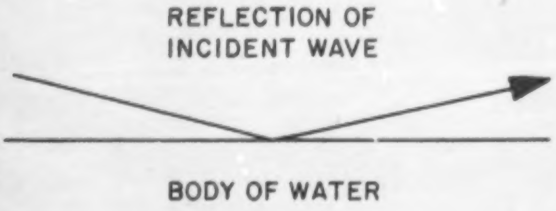
179.495



31.11
Figure 6-3.—Diffraction of Waves around a solid object.

encountered in the medium of travel. For reflection to occur, the object, or material doing the reflecting, must have the right type of surface, and it must be larger than the wavelength of the incident wave. Figure 6-4 shows an incident radio wave striking water. Water is a good conductor and reflector of radio waves. Large, smooth metal surfaces of good electrical conductivity (such as copper) are efficient reflectors.

As previously mentioned, reflection takes place only when the reflecting surface is large compared to the wavelength of the incident wave and smooth for an appreciable portion of a wavelength. When these conditions are not met, scattering occurs. Scattering is undesirable for certain types of communications, but it is utilized to a great extent in others.



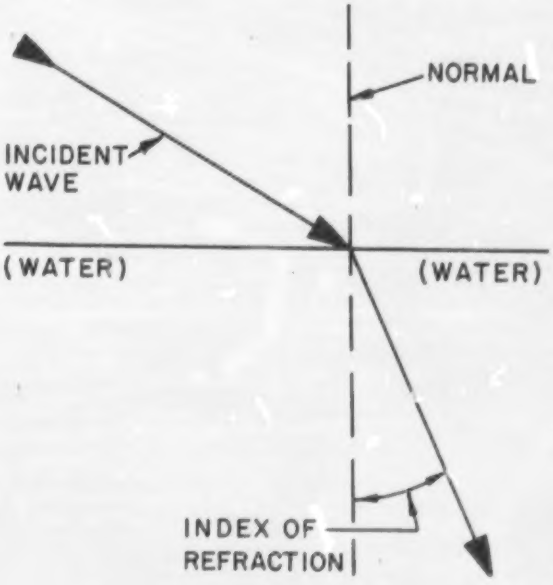
76.104
Figure 6-4.—Reflection of Incident Wave from body of water.

Refraction

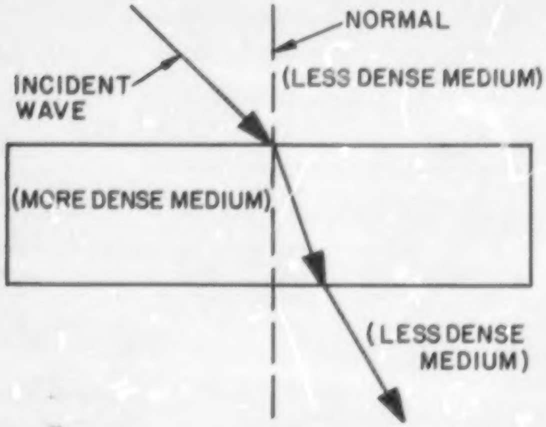
Whenever a radio wave passes from one medium into another of different density, it will be bent to some degree. Figure 6-5 shows a radio wave striking the surface of a body of water. The water, being more dense than air, tends to bend the radio wave back toward the "normal". The denser medium tends to slow and bend the radio wave. The amount of bending that takes place is referred to as the "Index of Refraction". The higher the index of refraction, the greater the bending.

Whenever a radio wave passes from a dense to a less-dense medium, it bends away from the normal. Figure 6-6 illustrates this principle. The "more dense" mediums and the "less dense" ones are normally layers that exist in the atmosphere. It must be remembered that whenever a radio wave is propagated, it is constantly being diffracted, reflected, and refracted, simultaneously.

A common error is the assumption that reflection and refraction are very similar because



76.105
Figure 6-5.—Radio Wave striking the surface of a body of water.

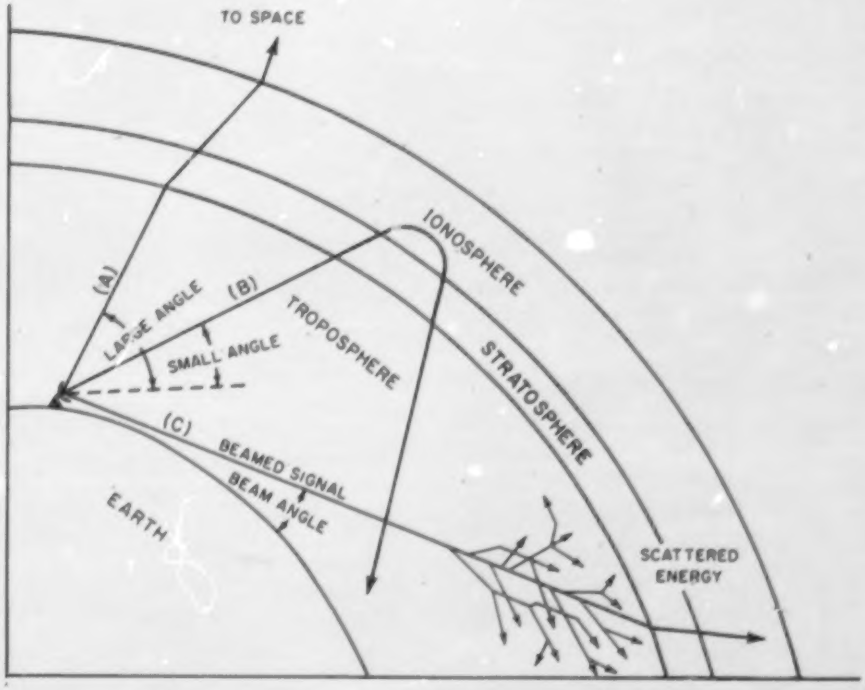

NORMAL
INCIDENT WAVE
(LESS DENSE MEDIUM)
(MORE DENSE MEDIUM)
(LESS DENSE MEDIUM)

76.106
Figure 6-6.—Radio Wave passing from a more dense medium to a less dense medium.

they return radio waves back to earth for reception. However, as shown in figure 6-7, the refracted wave is "bent" back to earth. As radio waves are propagated, some of them make large angles with respect to the horizontal along the earth (fig. 6-7(A)). These waves are refracted a small amount and pass on through the various layers of the atmosphere and into outer space. Still other waves of the same radio signal make small angles (fig. 6-7(B & C)), thereby travelling a greater distance in the layered medium and may be bent back towards earth gradually. The net result is as though the wave had been reflected back to earth.

COMPOSITION OF THE EARTH'S ATMOSPHERE

The atmosphere about the earth is not uniform. Changes in moisture content, temperature, and density occur at different heights and geographical locations or even with changes in

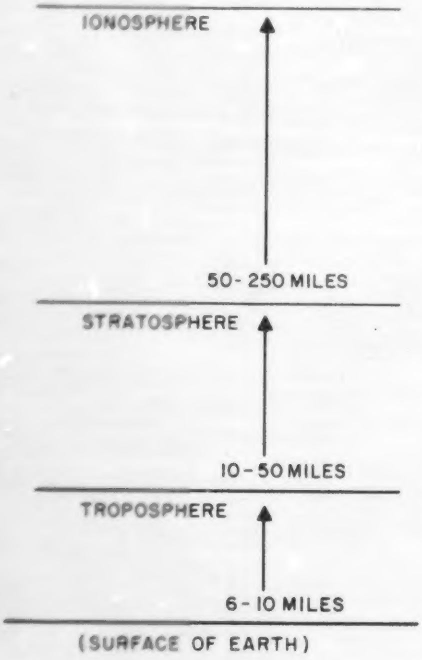

TO SPACE
IONOSPHERE
(A)
LARGE ANGLE
(B)
TROPOSPHERE
SMALL ANGLE
STRATOSPHERE
(C)
BEAMED SIGNAL
BEAM ANGLE
EARTH
SCATTERED ENERGY

25.93
Figure 6-7.—Refraction of Radio Waves in atmosphere.

time of day, night, season, or year. To assist in understanding the effects of these changes on radio waves, three regions have been identified in the atmosphere. These three regions are the troposphere, stratosphere, and ionosphere. Their positions with relation to each other are shown in figure 6-8. The troposphere extends from the earth's surface to heights of about 6 to 10 miles. The stratosphere, lying between the troposphere and ionosphere, extends from approximately 10 miles to 50 miles above the earth's surface. The ionosphere extends from approximately 50 miles to 250 miles above the earth's surface.

TYPES OF RADIO WAVE PROPAGATION

The radio wave that is transmitted from an antenna has two major components: the ground wave and the sky wave. The ground wave component of the transmitted radio wave consists of two parts. One part travels along the ground and follows the curvature of the earth and is called the surface wave. The second part is the space wave, which undergoes refraction, reflection, or scattering in the troposphere. The sky wave, is radiated in an upward direction and may be returned to earth at some distant location due to refraction or scattering from the ionosphere. The amount of bending of the sky wave by the ionosphere depends upon the frequency of the wave and the density of the layers in the ionosphere. The higher the frequency of the radio wave, the farther it penetrates the ionosphere, and the less it tends to be bent back toward earth.



76.107
Figure 6-8.—Positions of atmospheric mediums in relation to each other.

Surface Wave

A surface wave is that part of the ground wave that is affected chiefly by the conductivity of the earth and is able to follow the curvature of the earth's surface. The surface wave is not confined to the earth's surface. Parts of it extend upward to considerable heights in the troposphere, diminishing in strength as it increases height.

The earth itself is a partial conductor and, upon contact with its surface, some of the energy of the surface wave is absorbed and rapidly wasted in the form of heat. Losses suffered by surface waves are sometimes extensive, resulting in a badly attenuated (weakened) communications signal. The amount of attenuation depends on the relative conductivity of the earth's surface, which may vary according to terrain. Table 6-1 gives the relative conductivity for various types of surface. As can be seen, sea water is the best type of

Table 6-1.—Relative conductivity of surface types

Type of surface	Relative conductivity
Sea Water	Good
Large bodies of fresh water	Fair
Wet soil	Fair
Flat, loamy soil	Fair
Dry, rocky terrain	Poor
Desert	Poor
Jungle	Unusable

76.47

surface for surface wave transmission. Sea water makes possible the long-distance coverage attainable by fleet broadcasts that use surface wave transmissions of very low frequencies.

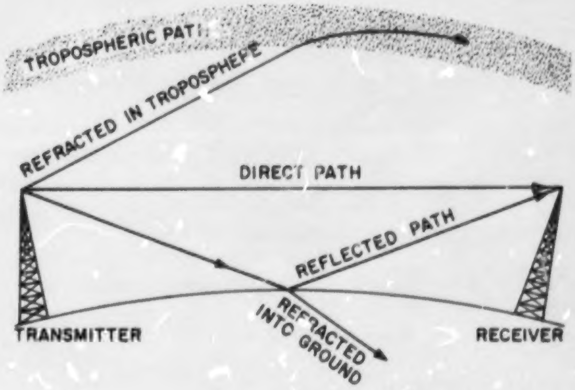
In general, the surface wave is transmitted as a vertically polarized wave and remains vertically polarized at appreciable distances from the antenna. Vertical polarization is used because the earth has a short-circuiting effect on a horizontally polarized wave. Overall, vertical polarization is superior to horizontal polarization except in heavily wooded or jungle areas. The reason is that most foliage grows vertically and absorbs vertically polarized energy.

Space Wave

While the characteristics of the surface wave serve to explain long-range propagation of very low frequencies using high power, they do not seem to apply to reception of higher frequencies within and slightly beyond the radio horizon. Such signals are considered to be propagated via the space wave.

Space waves are composed of two components: DIRECT WAVES and GROUND-REFLECTED WAVES. The direct waves travel in a direct line-of-sight path from a transmitting antenna to a receiving antenna. This component is limited only by the distance to the horizon (or line of sight) from the transmitter plus the small distance added by the atmospheric diffraction of the wave around the curvature of the earth. This distance can be extended by increasing the height of either the transmitting or receiving antenna, effectively extending the radio horizon. Figure 6-9 shows the possible routes that a ground wave might take.

A ground-reflected wave, as its name indicates, reaches the receiving antenna after it is reflected from the ground or sea. In figure 6-10, it may be seen that the waves start out with fronts of equal phase, continuing in phase up to the point of reflection of the ground component. Beyond this point, corresponding waves are 180-degrees out of phase. This phase reversal is important in determining the effect of the combining of the reflected wave with the direct wave upon arrival at the point of reception. Because the reflected wave travels a longer time in reaching its destination, a phase displacement (over and above the 180-degree shift caused by reflection) results. Thus, the reflected wave arrives at the receiving antenna, nearly 180-degrees out of phase with the direct wave. An undesirable cancellation of signal energy results.



31.12

Figure 6-9.—Possible routes for groundwaves.

Sky Wave

That portion of the radio wave which moves upward and outward and is not in contact with the earth is called the sky wave. It behaves similarly to the ground wave in that some of the energy is refracted, reflected, and scattered, and some of the energy is lost in dissipation within the atmospheric layers. A receiver located in the vicinity of the returning sky wave will receive strong signals even though the receiver is several hundred miles beyond the range of the ground wave.

Ionospheric refracted sky waves are generally the only usable waves for long range communications. Figure 6-11 illustrates some of the many possible paths that radio waves of various frequencies may take between a transmitter and a receiving station by refraction in the ionosphere. Notice that some of the waves, which are assumed to be of too high a frequency for refraction in the ionosphere, pass on through and are lost into space. Other radio waves, which are assumed to be of the correct frequency for refraction from the ionosphere, are returned to earth and provide communications.

In figure 6-11, notice that the term SKIP DISTANCE is the distance from the transmitting antenna to the nearest point at which the refracted waves return to earth. Also notice the difference between the skip distance and the SKIP ZONE. The skip zone is the zone between the end of the ground wave and the point where the sky wave first returns to earth. The skip distance depends upon the density of the ionosphere. The skip zone depends upon propagation characteristics of the ground wave in relation to the sky wave. The zone itself may vary from minute to minute for the same signal as propagation conditions change. Generally, however, the zone is relatively stable and remains approximately the same.

BASIC TROPOSPHERIC PROPAGATION

Tropospheric radio wave propagation depends on weather conditions. Weather conditions in the troposphere vary from minute to minute, making it the least predictable layer of the atmospheric medium. The troposphere is the lowest region of the atmosphere, extending from the earth's surface to a height of from 6 to 10 miles above the surface. Virtually all weather phenomena occur in this region of the atmosphere.

Refraction of radio waves in the troposphere is a function of various meteorological variables. Because of the uneven heating of the earth's surface, the air in the troposphere is in constant motion. This motion causes small turbulences, or eddies, to be formed. These turbulences are quite similar to whirlpools of water. The turbulence is at its greatest intensity near the surface of the earth and gradually diminishes with altitude.

Tropospheric Wave

A tropospheric wave is that component of the ground wave that is refracted in the lower atmosphere by rapid changes in humidity, atmospheric pressure, and temperature. At heights of a few thousand feet to approximately 1 mile, huge masses of warm and cold air exist near to each other, causing rapid changes in temperature and pressure. The resulting refraction and reflection make it possible to communicate over greater distances than that possible using the ground wave alone.

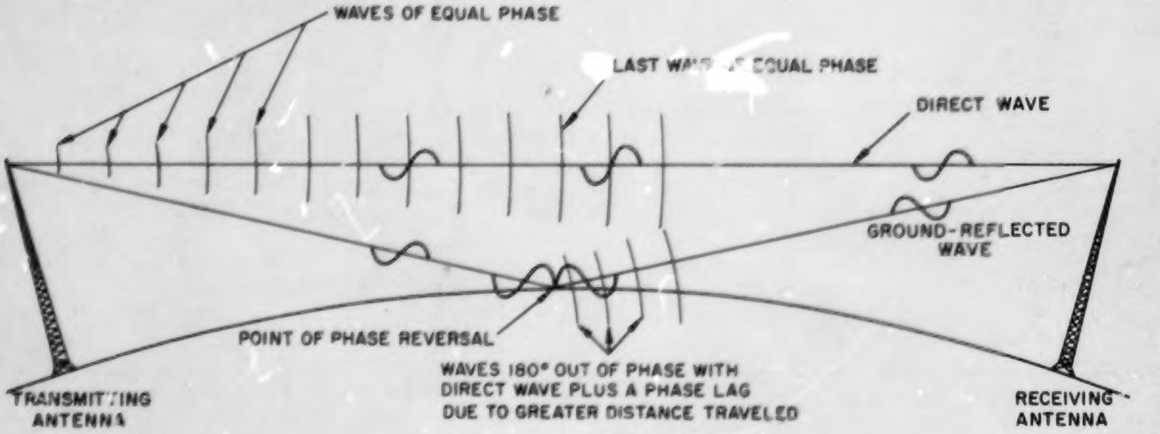
Temperature inversion is a common cause of tropospheric refraction, especially when warm layers of air are located above cooler layers. This may result from the rapid cooling of the earth's surface after sunset or the heating of air above a cloud layer by reflection of sunlight from the upper surface of clouds.

Forward Propagation Tropospheric Scatter Communications

The troposphere is used for many types of communications, such as radiotelephone, radioteletype, and data transmission. Much of this is made possible through a system known as forward propagation tropospheric scatter (FPTS), also known as "tropo-scatter". Basically, tropo-scatter utilizes the reflective and refractive properties within the troposphere. When a radio signal is beamed to an area in the troposphere, part of it goes through a complex series of partial reflection and refraction, causing energy to be scattered and to become partly diffused. This "beaming" is done via parabolic antennas such as those in figures 6-12 and 6-13. These antennas are very directional, hence lending themselves well to this type of communications. Figure 6-14 illustrates the way that these parabolics are used for tropo-scatter.

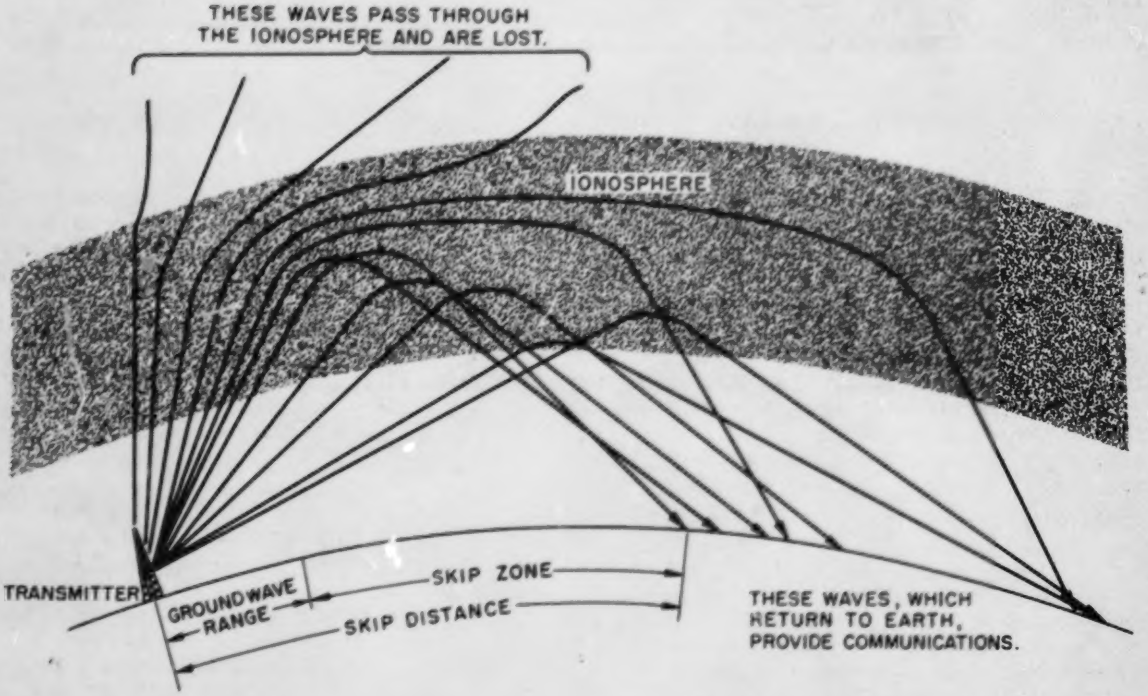
The scattering phenomenon in the troposphere is based on the theory that turbulences prevailing in the troposphere cause scattering of the signal beyond the horizon. The term "scattering" tends to imply that the signal is spread in all directions. However, this is not the case. A characteristic of tropo-scatter is that the energy in the main beam is scattered in a forward direction, hence the use of the term "forward-propagated". The lower the angle of the beam with respect to the horizon, the better the forward-propagation characteristics of the signal. A receiving parabolic, beamed at the same area in the troposphere as the transmitting antenna, will pick up the transmitted energy for further processing.

The amount of received energy decreases as the height of the scatter is increased. There are two reasons for this: (1) the scatter angle increases as the height is increased, thus decreasing the forward propagation characteristics,


WAVES OF EQUAL PHASE
LAST WAVE OF EQUAL PHASE
DIRECT WAVE
GROUND-REFLECTED WAVE
POINT OF PHASE REVERSAL
WAVES 180° OUT OF PHASE WITH DIRECT WAVE PLUS A PHASE LAG DUE TO GREATER DISTANCE TRAVELED
TRANSMITTING ANTENNA
RECEIVING ANTENNA

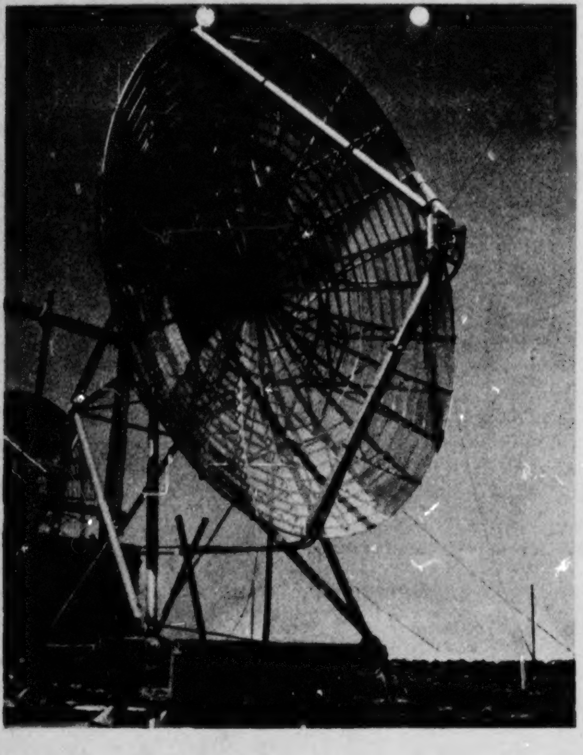
31.13

Figure 6-10.- Direct and Ground-reflected waves are out of phase.


THESE WAVES PASS THROUGH THE IONOSPHERE AND ARE LOST.
IONOSPHERE
TRANSMITTER
GROUNDWAVE RANGE
SKIP ZONE
SKIP DISTANCE
THESE WAVES, WHICH RETURN TO EARTH, PROVIDE COMMUNICATIONS.

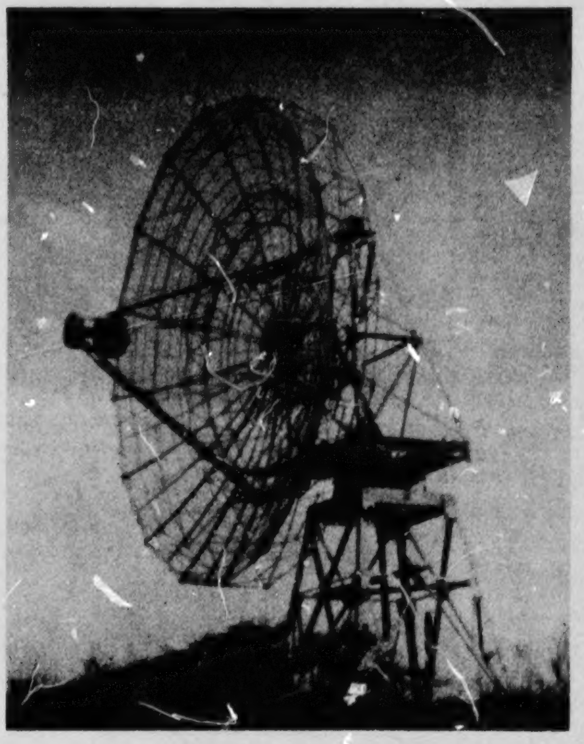
31.16

Figure 6-11.—Possible paths for radio waves.



76.58

Figure 6-12.—Mobile Tropo-scatter antenna.



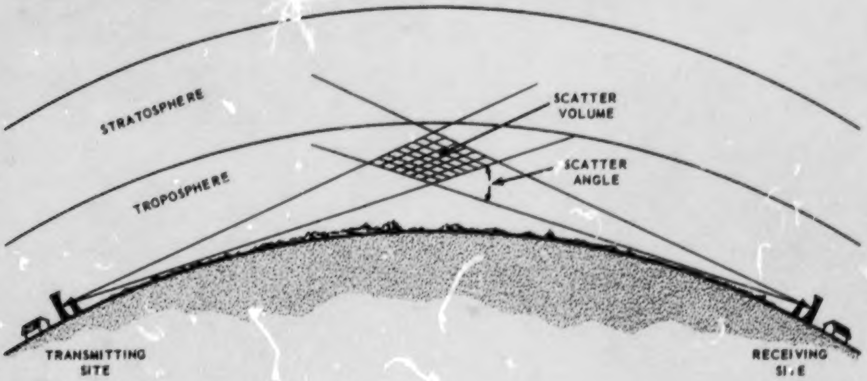
76.59

Figure 6-13.—Tropo-scatter antenna.

and (2) the amount of turbulence decreases with the height in the troposphere, thus reducing the amount of reflection and refraction taking place at any one time in the beamed signal. It should be noted that as greater distance is attempted with FPTS, the received signal level decreases. This is because the angle must be increased to achieve greater height, thus decreasing the receive potential. The beam take-off angle of transmitting and receiving antennas for FPTS is always kept as low as possible, depending upon local terrain and general geographical location.

Since tropospheric scatter depends on turbulences in the atmosphere, changes in atmospheric conditions will affect the received signal level. Both daily and seasonal variations are noted. These changes are associated with a term known as "long-range fading" characteristics. There is also a term known as "rapid-fading", which is associated with multi-path transmissions or multi-path propagation. The signals received at any one time are the sum of all the signals received from each of the turbulences in the main beam. Since turbulent conditions are constantly changing, the transmission paths and individual signal levels are also changing, resulting in a rapidly changing signal. Although the signal level is constantly changing, the average signal level is relatively consistent. Therefore, no complete signal fade-out occurs.

Another characteristic of a tropospheric scatter signal is that most of the transmitted beam is not picked up by the receiving antenna, the efficiency is very low, and the signal level at the receiving station is very low. To compensate for this low efficiency in the scatter, the incident power must be high. Thus, high-power transmitters and high-gain antennas are used to concentrate the transmitted power into the beam, thus increasing the intensity of energy radiated. The receiving antennas are also very



50.148

Figure 6-14.—Tropo-scatter propagation.

sensitive, thus enabling them to detect low-level signals for further processing. Since troposcatter is considered to be relatively short-range, a series of relay stations with built-in signal amplifiers are used to achieve long-range transmission.

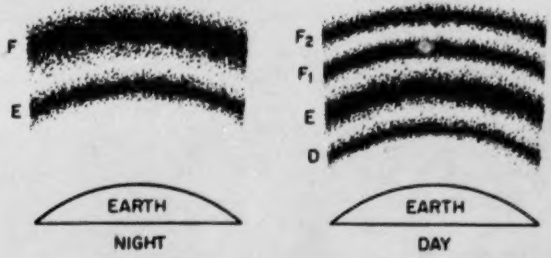
BASIC IONOSPHERIC PROPAGATION

The ionosphere is found in the rarefied atmosphere, beginning at approximately 40 to 50 miles above the earth. It differs from other atmospheric layers in that it contains a much higher number of positive and negative ions. It is known that the atmosphere is under constant bombardment by radiation and particle showers from the sun as well as by cosmic rays. Radiation from the sun includes not only light rays that can be seen, but also the entire spectrum, ranging from infrared rays to ultraviolet rays. Radiation from the sun is capable of dislodging some loosely bound electrons from gas atoms that make up the dense gases in the upper atmosphere. Therefore, the ionosphere has a large number of ionized gas atoms as well as free electrons unassociated with any atom.

At altitudes above 350 miles, the particles of air are far too sparse to permit large-scale energy transfer. Ultraviolet radiations from the sun are absorbed in passage through the upper layers of the ionosphere so that below an elevation of 40 miles, very few ions exist that would affect sky wave communications. Therefore, sky wave communications depends primarily upon the ionospheric conditions existing at the time of transmission.

Densities of ionization at different heights make the ionosphere appear to have layers. Actually, there is thought to be no sharp dividing line between the various layers, but they do exist and will be separated here for explanation and clarity.

Figure 6-15 shows the various layers associated with the ionosphere at night and during the day. The ionized atmosphere at an altitude of between 40 and 50 miles is called the "D" layer. Its ionization is low and has little effect on the propagation of radio waves except for the absorption of energy from the



13.28

Figure 6-15.—Ionospheric layers at night and during day.

waves as they pass through it. The D layer is present only during the day. Its presence reduces the field intensity of radio wave transmissions during the day.

The "E" layer exists at altitudes between 50 and 90 miles. It is a well defined layer with greatest density at an altitude of about 70 miles. This layer is strongest during daylight hours and is also present, but much weaker, at night. The maximum density of the E layer appears at about mid-day. During this part of the day, the ionization of the E layer is sometimes sufficient to refract frequencies in the upper HF band back to earth. This action is of great importance to daylight transmissions for distances up to 1,500 miles.

The "F" layer extends approximately from the 90 mile level to the upper limits of the ionosphere. During daylight hours the F layer is divided into two sections: the F_1 and the F_2 layers. Shortly after sunset, the F_1 and the F_2 layers combine into the single F layer.

In addition to the layers of ionized atmosphere that appear regularly, erratic patches of ionized atmosphere occur at E layer heights in the manner that clouds appear in the sky. These patches are referred to as "Sporadic-E" ionizations. These sporadic ionizations may appear in considerable strength and prove quite harmful to electronic transmissions.

Effect Of Ionosphere On The Sky Wave

The ionosphere has many characteristics. Some waves penetrate and pass entirely through it into space, never to return. Other waves penetrate but bend. Generally, the ionosphere acts as a conductor and absorbs energy in varying amounts from the radio wave. The ionosphere also bends (refracts) the sky wave back to the earth, as shown in figure 6-16.

The ability of the ionosphere to return a radio wave to the earth depends upon the angle at which the sky wave strikes the ionosphere, the frequency of the radio wave, and the ion density. When the wave from an antenna strikes the ionosphere at an angle, the wave begins to bend. If the frequency and angle are correct and the ionosphere is sufficiently dense, the wave will eventually emerge from the ionosphere and return to earth. The sky wave in figure 6-17 is assumed to be composed of rays that emanate from the antenna in three distinct groups that are identified according to the angle of elevation. The angle at which the group 1 rays strike the ionosphere is nearly vertical and will not be returned to earth. The radio wave strikes the ionosphere, is bent out of line slightly, but passes completely through the ionosphere and is lost.

The angle made by the group 2 waves is called the CRITICAL ANGLE for that frequency. Any wave that leaves the antenna at an angle greater than this angle (θ) will penetrate the ionosphere.

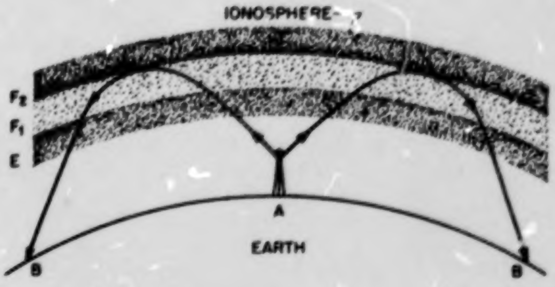


Figure 6-16.—Ionosphere "bends" waves back to earth.

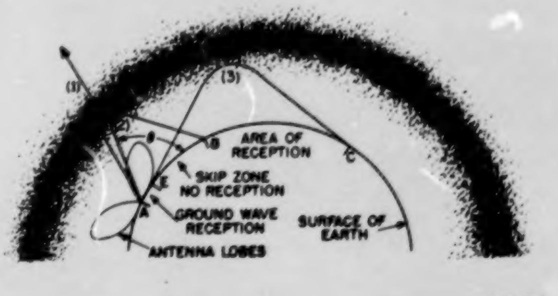


Figure 6-17.—Three groups of radio waves according to angle of elevation.

Group 3 waves strike the ionosphere at the smallest angle that will be refracted and still be returned to earth. At any smaller angle, the waves will be refracted but will not return to earth.

As the frequency increases, the initial angle decreases. Low frequencies can be projected straight upward and will be returned to the earth. The highest frequency that can be sent directly upward and still be refracted back to the earth is called the CRITICAL FREQUENCY. At sufficiently high frequencies, regardless of the angle at which the rays strike the ionosphere, the wave will not be returned to earth. The critical frequency is not constant but varies from one locality to another, with the time of day, with the season of the year, and with the sunspot cycle.

Because of this variation in the critical frequency, frequency tables are issued that predict the maximum usable frequency (MUF) for every hour of the day for every locality in which transmissions are made. These frequency tables are prepared from data obtained experimentally from stations scattered all over the world. All of this information is pooled, and the results are tabulated in the form of long range predictions that remove some of the guesswork from transmissions.

Absorption In The Ionosphere

As a radio wave passes into the ionosphere, it loses some of its energy to the free electrons and ions contained in this part of the atmosphere. Since absorption of energy is dependent upon collision of particles, the greater the density of the ionized layer, the greater the probability of collision, and therefore, the greater the absorption. The highly dense D and E layers provide the greatest absorption for the ionospheric wave.

Variations In The Ionosphere

Sky wave intensity varies from minute to minute, month to month, and year to year because of variations in the ionosphere. Since the ionosphere exists primarily because of the radiation of the sun, any variation in the strength of this radiation will cause a corresponding change in the ion density of the upper atmosphere. Some of the variations in the ionosphere are periodic and their effects on radio frequencies can be anticipated. Others are unpredictable, and while their effects are pronounced, there is little that can be done but to realize that they may occur. Periodic variations can be divided into daily, seasonal, and sunspot cycle variations. Unpredictable variations are usually the result of the sporadic E layer and Short Wave Fadeouts (caused by sudden solar flare-ups).

Periodic Variations

Daily variations are caused by the 24-hour rotation of the earth about its axis. In the daytime, the ionosphere consists of the four ionized layers previously mentioned. At night in the F region, only the F2 layer exists insofar as regular HF propagation is concerned. The nighttime F2 layer is formed by a combination of the daytime F1 and F2 layers that merge during evening hours.

Seasonal variations occur as the intensity of the ultra-violet light which reaches any given spot in the earth's atmosphere varies with the position of the earth in its orbit around the sun.

Sunspot activity varies in conformance to an 11-year cycle. Sunspots are proportional to approximate solar radiation and to the total ionization of the atmosphere. During periods of high sunspot activity, ionization of various layers is greater than usual, resulting in higher critical frequencies for the E, F1, and F2 layers, and higher absorption in the D layer. Consequently, higher frequencies can be used for communication over long distances at times of greatest sunspot activity. Increased absorption in the D layer, which has the greatest effect on the lower frequencies, requires higher frequencies. The overall effect is a general improvement in propagation conditions during years of maximum sunspot activity.

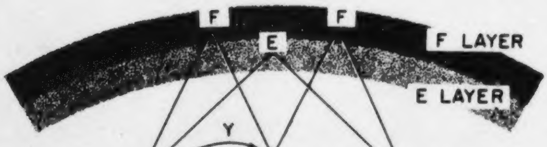
FADING

Fading is the variation of radio signal strength at the receiving end of a transmission. Signals received over an ionospheric path may vary in intensity over short periods of time. There are three major reasons for fading. When the radio wave is refracted in the ionosphere or reflected from the earth's surface, random variations in polarization of the wave may occur, causing changes in the received signal level because of the inability of the antenna to receive polarization changes. Fading may also occur if the operating frequency selected is too close to the MUF (Maximum Usable Frequency). If this is the case, any slight change in the ionosphere might cause a change in signal strength. Fading also results from absorption of the signal energy in the ionosphere. Absorption fading occurs for a longer period of time than other types of fading because of the length of time required for an ionized layer to change in ionization potential. However, the major cause of fading on ionospheric circuits is caused by multipath propagation.

Multipath Fading

"Multipath" is the term used to describe the types of propagation that undergo changes en route to the receiving site, causing them to arrive in a time frame that is later than the signal reflected from the ionosphere.

Figure 6-18 shows the various paths a signal can travel between two sites. One signal, the ground wave, may follow the path XYZ. Another signal, refracted from the E layer (XEA), is received at A, but not at Z. Still another path (XFZFA), results from a greater angle of incidence and two refractions from the F layer. At point Z, the received signal is a combination of the ground wave and the sky wave. If these two waves are received out of phase, they will produce a weak or fading signal. If they are received in phase, the waves will produce a stronger signal. Small alterations in the transmission path may change the phase relationship of the two signals, causing periodic fading. This same addition of signal components occurs at point A. At this point, the double-hop signal from the F layer may be in or out of phase with the signal arriving from the E layer.



20.254

Figure 6-18.—Various paths of signal travel.

Selective Fading

Fading resulting from multipath propagation is variable with frequency since each frequency arrives at the receiving site via a different path. When a wide band of frequencies, such as multichannel single sideband, is transmitted, the frequencies in the sideband will vary in the amount (if any) of fading. This variation is called selective fading. Whenever selective fading occurs, all frequencies within the envelope of the transmitted signal may not retain their original phase relationship and relative amplitudes. This fading may cause severe distortion of the signal and limit the total bandwidth which can be transmitted.

FREQUENCY BANDS AND CHARACTERISTICS

For practical purposes, it is convenient to classify RF emissions into frequency bands (see Table 6-2). Whereas each band of frequencies has similar propagation effects, they also have very recognizable differences. These differences are not always sharply defined because of the nearness of the upper ends of some bands with respect to the lower end of the next higher band. The greatest difference in propagation characteristics occur near mid-band between two bands. Normally, when an upper or lower limit of frequency is designated for a certain propagation effect, it does not mean that such an effect stops at those limits, but that it becomes negligible beyond such limits.

Medium-Frequency Band (MF)

Only the upper and lower ends of the MF band (0.3 - 3 MHz) have naval use because of the commercial usage of this band near mid-range (0.55 - 1.70 MHz). Frequencies in the lower portion of the MF band are used mainly for ground wave transmission for moderate distances over water and moderate to short distances over land. The Navy utilizes the upper portion of the MF band (2 - 3 MHz) quite extensively. The range of communication in the upper portion is generally moderate and dependent upon the type of antenna used and the output power of the transmitter. Usually, because of the rather long antennas required, this band is utilized with horizontal wire antennas where antenna space is unrestricted. In mobile applications, whip antennas are normally used in this frequency range.

Table 6-2.— Radio-Frequency Spectrum

FREQUENCY	DESCRIPTION	ABBREVIATION
30GHz-300GHz	extremely high frequency	EHF
3GHz-30GHz	super high frequency	SHF
300MHz-3GHz	ultra high frequency	UHF
30MHz-300MHz	very high frequency	VHF
3MHz-30MHz	high frequency	HF
300kHz-3MHz	medium frequency	MF
30kHz-300kHz	low frequency	LF
3kHz-30kHz	very low frequency	VLF

31.20

High-Frequency Band (HF)

The HF band (3 - 30 MHz) employs ionospheric propagation for long-range sky wave communication. The HF band is the principal frequency range used for Navy ship-to-shore communication circuits. Communications publications that predict propagation conditions for this band are published periodically, (NTP-6, Supp-1 Series).

Ultra-High Frequency Band (UHF)

Almost all of the energy transmitted from point to point in the UHF band (300 - 3000 MHz) is propagated through the troposphere along a curved path. The refracted path may be assumed to be a straight line path extending to distances of approximately four-thirds times the true horizon. However, the transmission range of this band may be extended several hundred miles further by means of tropo-scatter propagation.

Ground reflections are still present at ultrahigh frequencies and can cause multipath fading due to interference, although such reflections become less important at the higher end of this band. However, a second type of multipath fading can occur when parts of the wave are refracted through higher layers of the atmosphere and become bent sufficiently to return and combine with the wave received over a lower, more direct path.

Atmospheric and man-made noise in this frequency band is extremely low. Most noise encountered emanates from the equipment itself, both transmitting and receiving. This is due to the circuit design inherent in most UHF equipments. Because of the increased frequency, component parts and assemblies are normally smaller and spacing more critical. Inductive and capacitive reactances are normally high, hence the greater noise associated with UHF equipment.

Super And Extremely High Frequencies (SHF and EHF)

The Super and Extremely High frequency bands have very limited application in Naval Communications. Although future plans call for the use of these two frequency bands, the primary utilization at the present time is in the lower SHF band (3-13 GHz) for satellite communication systems.

Transmission at the SHF and EHF bands is very difficult because of the nature of the radiated wave. Wavelengths at these frequencies are very small, causing a great deal of reflection of the incident wave. Almost any object will act as a reflecting surface in this frequency range, almost as if the atmosphere were made up of an infinite amount of small mirrors, each reflecting the incident wave in a different direction. This phenomenon is sometimes called DIFFUSE REFLECTION and is quite prevalent in the SHF and EHF frequency ranges. In addition, incident radiation will also be absorbed by the earth's vegetation. Even rain can cause scattering and absorption in these frequency ranges. If the drop size is comparable to the wavelength of the propagated wave, a substantial portion of the transmitted energy will be reradiated from the raindrop in many directions. This phenomenon, known as SCATTERING, has an attenuating effect on radio waves. The attenuating effect is caused by the incident energy that is absorbed and virtually trapped and converted into heat.

The potential losses inherent at this frequency range are overcome through the use of sharply beamed incident waves utilizing very directional transmitting antennas. The use of directional antennas (such as parabolics) not only enhances transmission success, it also ensures the conservation of necessary incident power.

CHAPTER 7

BASIC TEST EQUIPMENT

Communications personnel have become dependent upon electrical and electronic equipment to perform their day-to-day tasks. This has been made necessary by the vastness and complexity of communications itself. It has been proven that the effectiveness of naval tactical and nontactical forces is to a large extent dependent upon communications. Therefore, the reliability of communications equipment must be maintained at all times. Many factors enter into determining the reliability of the equipment. One is the quality of the equipment itself. Another is the ability of operating personnel to properly perform their jobs. Lastly, and perhaps most important, is adequate maintenance.

Maintenance is work done to correct, reduce, and counteract wear and damage to equipment. Maintenance of communications equipment is divided into two main categories: PREVENTIVE (routine) maintenance and CORRECTIVE maintenance. Preventive maintenance consists of routine checks, made periodically, to determine whether the equipment is functioning properly. Preventive maintenance usually consists of visual inspection of equipment component parts and wiring for damage and wear, as well as periodic lubrication and component adjustment procedures. Corrective maintenance is used to isolate equipment troubles (by means of test techniques and practices), to replace defective parts, and to realign and readjust equipment or to otherwise bring the equipment back to proper performance.

Depending upon your level of skill, you will have to make many preventive checks on communications equipment. It is necessary that all communications operating personnel be able to make routine trouble-checks on the equipment that they operate. It is usually through the routine checks of operating personnel that potential problems are detected and corrected before they can become major problems. It is not always necessary that you, as an operator, be able to repair electronics equipment. However, many preventive checks made by communications personnel involve the use of basic test equipments. Without a knowledge of the more basic types of test equipment and their various principles of operation, potential problems could go undetected.

CARE, USE, AND HANDLING OF TEST EQUIPMENT

Nearly every communications center is provided with a variety of test equipment to be used when preventive or corrective tests are made. Normally, there are very few, if any, test equipments in spare. When a test set becomes inoperative, the ability to make basic trouble-checks suffers. Therefore, protecting test equipment from general harm that results from dropping, falling, careless misuse, or improper operating techniques is a must.

One of the primary causes of test equipment failure is carelessness. The user may be careless in operating procedures or in simple handling of test equipment. Any doubts about the proper usage of a test set should be referred to the technical manual issued with the set. Often, test equipment is placed near the edge of a bench or table where it can be pulled off by test leads or accidentally knocked off. Another error made by many operating personnel is improper selection of meter ranges, such as attempting to measure 250 volts on the 50 volt scale of a meter.

Some test equipments may require special handling. However, there are several precautions which apply to test equipments in general. Rough handling, moisture, and dust all affect the useful life of test equipments. Bumping or dropping a test instrument may destroy the equipment's ability to properly measure what it was designed for. Creasing or denting test cables that attach to a test set will alter their internal resistance, thereby affecting the accuracy of any measurements made with these cables.

To reduce the danger of corrosion to untreated parts, always store test equipment in a dry place when it is not in use. Be sure that all assembly screws that hold the case of the test equipment in place are securely tightened. As an added precaution, all dust covers should be placed on test equipments when they are not in use. Lockers containing test equipment should be padded in order to reduce shock onboard ship whenever the ship rolls or pitches.

Meters are the most delicate parts of test equipments. In order to ensure that the meter will maintain its accuracy, these additional precautions should be followed:

1. Ensure that the amplitude of the circuit under test is within the range of the meter.

2. Keep meters as far away as possible from strong magnets.

The instructions for properly stowing test equipment cables and other accessories, as set forth in the instruction manuals accompanying the equipment, should be carefully read and strictly followed. Improper stowage of accessories results in changes in cable characteristics, intermittent short circuits in cables and leads and, in general, unreliable test indications.

SELECTION OF TEST EQUIPMENT

The term "testing", as used in reference to test equipment, refers to the use of test sets to determine or to evaluate the condition or quality of operation of a unit, circuit, or component. Proper testing procedures must begin with the selection of the test equipment. This equipment must be used in accordance with specified procedures. The results must be evaluated in reference to normal, specified standards.

Electrical equipments are designed to operate at certain efficiency levels. To aid operators and maintenance personnel, technical manuals and sheets containing optimum performance data, such as voltages and resistances, are prepared for Navy equipment. A good understanding of the functional design and operation of the equipment to be tested is very important. A thorough understanding of the operation and limitations of the measuring instrument (or instruments) is most essential in test equipment selection.

The first requirement of any test equipment is its ability to perform the test required. Secondly, it must be compatible with the equipment under test. Basically, compatibility can be narrowed down into 4 areas: impedance matching, frequency, amplitude, and polarity.

Impedance Matching

Anytime that you connect a piece of test equipment to another piece of equipment to be tested, you are essentially "loading" the circuit (or circuits) under test. This means that the test equipment will be either in series with the circuit (or circuits) under test, or it will be in parallel with them. Therefore, reactive components as well as resistive components are involved within the test set and the equipment under test.

To ensure continuity between the test equipment and the measured electronic equipment is normally no more complex than choosing the right test equipment and using the cables and adapters supplied with the test set. Most items of electronic and test equipment are rated according to input and/or output impedances. Cables and adapters are usually supplied with test sets used in testing of electronic equipment. The test procedures, normally found in Maintenance Standards Books or equipment Technical Manuals, contain itemized lists of test equipment (or equipments) required for a specific test. Preventive Maintenance items are usually found on Maintenance Requirement Cards (MRCs). By using these specified items, adequate impedance matching is ensured. Substitution of cables and fittings for those supplied with the test equipment frequently causes mismatching of impedance and results in erroneous test results.

Frequency

Another important consideration in the selection of test equipment involves the respective frequency range(s) of the test set and the equipment under test. Equipment that is designed to supply test frequencies must supply frequencies within the frequency range(s) needed as well as be responsive to the needed bands of the input and output tuned circuits of the equipment under test.

Amplitude

To test the output of a circuit, the test set must have sufficient sensitivity to respond to the measured signal. Conversely, the circuit under test must be sensitive to respond to the signal injected by the test equipment. In both cases, we are talking about amplitude. The amplitude of either signal must be of sufficient magnitude to create the proper response. However, signal amplitudes must not be so large as to damage circuits under test or the test equipment itself. If signals are too large, provisions are normally made via front-panel controls to reduce their size through proper attenuation. Amplitude problems can be eliminated through proper attention to operating instructions and precautions.

Polarity

Test equipment used in checking the operation of many circuits must be able to generate or respond to a particular polarity signal. An example of this is a test set used to check synchronous motor circuits. Signals having the wrong polarity would fail to activate the synchro circuits, thus falsely indicating a malfunction. Therefore, observe proper polarity, both in test-lead hook-up and in the generated or tested signal.

CALIBRATION OF TEST EQUIPMENT

To "calibrate" a piece of test equipment is to determine, by measurement or comparison with a standard, the correct value of each scale reading on a meter or other device. To further explain, test equipments are the reference standards used in preventive or corrective maintenance procedures. For this reason, maintenance and test of the test equipment itself is correspondingly more critical. Therefore, we calibrate our test equipment. We accomplish this by comparing test equipment outputs against known, more accurate instruments than the one that we are checking. Calibration instructions are normally contained in the applicable technical manual or on the applicable maintenance requirement card (MRC).

Much of the test equipment now being furnished to naval activities and communications centers is very expensive and is built and calibrated to a high order of precision. Repair and recalibration quite often require special laboratory facilities and skill. In many cases, personnel not qualified by reasons of education, experience, and/or adequate facilities have attempted to make repairs to precision portions of electronic test equipment. While you, a communications operator, may be called upon to operate test equipments and make basic trouble-checks, remember that repair of test equipment is normally the job of personnel specifically trained for it. Often, even calibration of a test set is involved enough to warrant laboratory conditions and specific skills.

Many personnel are reluctant to calibrate test equipments aboard ship. The principal reason for this is the belief that test equipment cannot be calibrated except with special calibrating instruments. However, in many cases, test equipment is available aboard ship that is sufficiently accurate to calibrate other test equipment.

Calibration of one piece of test equipment with another requires that the calibrating instrument be more accurate than the instrument being calibrated. Ideally, the calibrating instrument should be about ten times more accurate. However, this extreme accuracy is not always necessary. If either repair or calibration is beyond the capabilities of shipboard personnel, the equipment should be forwarded to the nearest maintenance activity that has adequate repair and calibration facilities, depending upon at-sea status. Always be sure that you have read the Technical Manuals of both the "Calibration Standard" and the instrument to be calibrated.

THE BASIC MEASUREMENTS OF TEST EQUIPMENT

When test equipment is used, the basic communication and electronic measurements involve the fundamental electrical quantities of voltage and current and the inherent circuit characteristics of resistance, capacitance, and inductance. In the circuits under test in communications equipment, the voltage and current are dependent for their distribution upon the latter three;

therefore, voltage and current measurements are a valuable aid in determining circuit conditions and in the evaluation of symptoms. Practically any reading derived from the use of test equipment will depend upon these basic measured quantities.

Voltage Checks

Voltage measurements may be made as part of preventive maintenance or as part of corrective maintenance. Normally, test jacks are located on equipment front panels or on the top of pull-out equipment drawers, providing convenient "point-to-point" voltage checkpoints. Voltage measurements, when compared with available voltage charts provided with the equipment, are valuable aids in determining potential problems as part of preventive maintenance. The measuring device used to check voltages is called a VOLTMETER.

Current Measurements

Current measurements, as a rule, are not often taken in the course of preventive maintenance or in testing. They are infrequently used because in most cases the circuit under test must be opened (unsoldered) for the necessary meter connections. The measuring device used for current measurements is called an AMMETER.

Usually, a voltage measurement and a calculation by means of Ohm's law are sufficient to determine circuit current, when necessary. Another reason for the infrequency of this measurement is that most circuits are of a high resistive value overall, and the current is normally so low that it cannot be measured accurately with ordinary test equipment.

Resistance Checks

Resistance measurements are normally a valuable aid in locating trouble circuits during corrective maintenance. Hence, many maintenance handbooks contain resistance charts which are referenced to accessible points (usually tube sockets) within the equipment. Without these charts, resistance measurements in a complex circuit is a slow process, sometimes necessitating the unsoldering of one side of circuit components.

Normally, resistance measurements are not made as part of preventive maintenance, but when they are, the device used is called an OHMMETER. Because of the degree of accuracy needed when using an ohmmeter, proper calibration and understanding of meter scales is a must.

Capacitance Measurements

Capacitance measurements are usually accomplished with a CAPACITANCE METER. The basic capacitance measurement is an indication of that capacitor's dielectric strength. As the dielectric strength of a capacitor decreases, leakage current through it will increase. The tolerance of a particular capacitor will vary depending upon the type of capacitor and its voltage rating. Capacitance measurements are very useful in component testing to determine overall stage efficiency.

Inductance Measurements

Inductance measurements are seldom required in the course of preventive or corrective maintenance. However, when called for, inductance measurements are useful and instruments are available for making this test. Many capacitance test sets can be used to measure inductance. Most manufacturers of capacitance test sets furnish inductance conversion charts if the test equipment scale is not calibrated to read the value of inductance directly.

TYPES OF METERS

The primary indicating component in any electrical indicating instrument is usually a pointer which gives the desired reading on a calibrated scale. The pointer is usually attached to a "moving element" that turns or rotates when energized by the current of the circuit under test or a proportional part of that current. This causes the pointer to move proportionally along the calibrated scale.

There are two types of meters that use this principle of operation: ELECTRONIC and NON-ELECTRONIC. Non-electronic meters use the inherent electromagnetism of electronic circuits to provide the essential measured information. Electronic meters normally make use of internal electronic components and conversion circuits to get the proper scale indication on the meter front panel. Either type of meter may be designed for use in a.c. circuits or d.c. circuits.

126

The power consumption of any electrical measuring device should be very small in comparison with the power available in the circuit under test. Normally, an a.c. meter uses several times as much power as a similar d.c. meter.

All meters must have some source of power. Some meters are powered by internal batteries. Others are powered through electrical power provided by electrical plug-in outlets. Still others are powered by a hand-operated hand crank attached to the meter itself. Most meters are designed to be used for measuring more than one electrical quantity and are called MULTIMETERS. Figure 7-1 is an example of a multimeter. This particular multimeter is a TS-505. It is used as an example because it shows most of the basic components associated with practically any piece of test equipment. Shown are the test probes (bottom of case), operating front-panel controls (left, right and center of case), and the indicator scale and associated pointer.

Common Meter Controls

The following is a list of front-panel controls that normally serve the same function, regardless of meter type (figure 7-1 may be referred to):

1. FUNCTION switch: Selects the type of meter operation desired and normally turns the meter on or off.

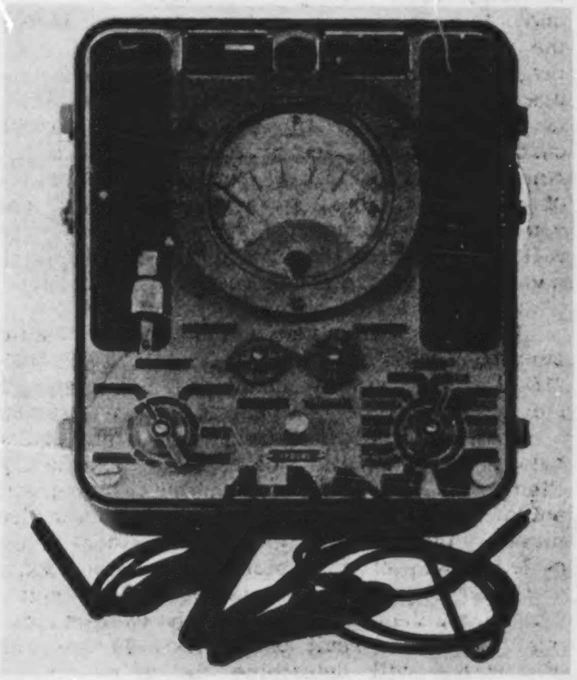
2. RANGE switch: Selects various voltage or resistance scale values to be measured.

3. ZERO ADJ switch: Controls the pointer on the indicator scale. May be used to set the meter pointer at zero, mid-scale, full-scale, or any other meter quantity visually measured.

4. AC LINE cord: Connects the meter to an a.c. power source.

5. Pilot light indicator: Lights whenever power is applied to the meter (located directly above the pointer scale in figure 7-1).

After you are more experienced with the more common operating controls of test meters, you will find much of meter operation self-explanatory. However, even the most experienced user of test meters should study the technical manual for the particular test set and its proper operating procedures outlined therein. Barring the availability of a technical manual, you should be instructed under the direction of your work center supervisor.



4.133

Figure 7-1.—TS-505 Multimeter.

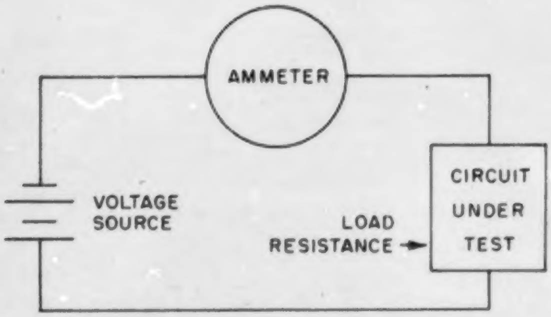
COMMONLY USED TEST EQUIPMENT

During your naval career, you will use many types of test equipment as part of preventive or corrective maintenance. The following is a discussion of the more commonly used types of test equipment and functional facts concerning each.

Ammeters

Ammeters are used to measure the intensity of current flow in a circuit. Ammeters are connected in series with the circuit under test, as shown in figure 7-2. The accuracy of an ammeter reading depends upon the meter resistance relative to the resistance of the circuit under test (load resistance). As previously stated, the larger the resistance of the meter, the larger will be the percent of error in the measurement. For example, if the meter resistance is equal to the load resistance, the circuit current will be twice as much with the meter removed from the circuit, representing an error of 50 percent. Thus, for any given circuit load condition, the accuracy of an ammeter reading will be greater if the total meter resistance is much less than the ohmic resistance of the load.

Most ammeters use a method of indicating current known as the D'ARSONVAL MOVEMENT. This simply means that a fixed-length piece of conductor is wound many times around a core (essentially becoming a coil) and placed betwen two magnetic poles (North and South). Figure 7-3 shows the coil and the two magnetic poles. Also shown is the attached pointer that moves along a calibrated scale. Basically, the coiled length of conductor is of a fixed value and the magnetic field is of a fixed value. Therefore, the only variable is the current flowing from the circuit under test. The amount of current will determine the field strength between the two magnetic poles, thereby determining the amount of pointer movement (referred to as meter "deflection"). The balance springs indicated in figure 7-3 are sometimes referred to as "hairsprings" and serve as the restoring force that returns the pointer to the zero position when no current flows. These hairsprings also serve to complete the circuit from the external circuit to the meter coil.



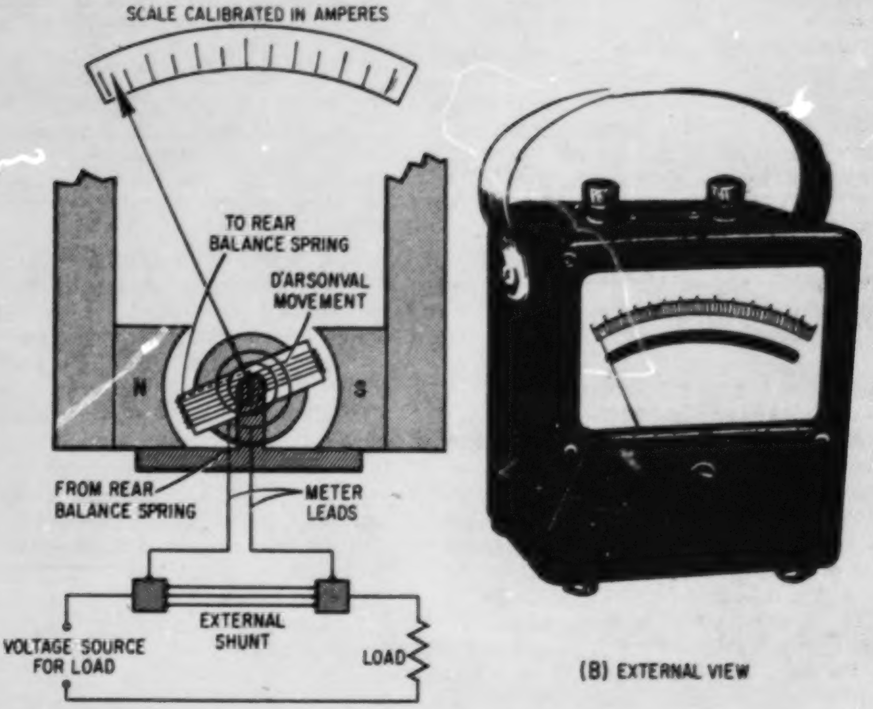
76.108
Figure 7-2.—Ammeters are normally connected in series with the circuit under test.

The small size of the wire which comprises the ammeter coil places limits on the amount of current that may be passed through it. Consequently, the basic meter movement thus far discussed is used to measure only very small amounts of current.

In order to measure a larger current, a SHUNT must be used with the meter. A shunt is a physically large, low-resistance conductor which is connected in parallel (shunt) with the meter terminals. It is used to carry the majority of the load current. (See figure 7-3.) The shunt has the correct amount of resistance, enabling only a small amount of the total current to flow through the meter coil. The meter current will be proportional to the total load current. If the shunt has such a value that the meter is calibrated in milliamperes, the instrument is called a MILLIAMMETER. If the shunt is of such a value that the meter must be calibrated in terms of amperes, it is called an AMMETER.

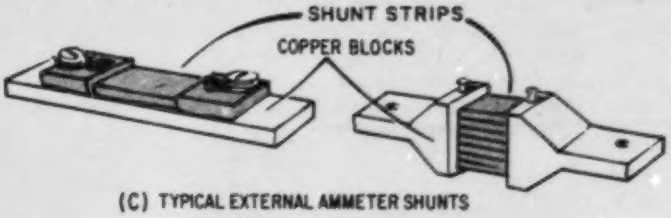
A single standardized meter movement is normally used in all ammeters, no matter what the range is for a particular meter. For example, meters with working ranges of zero to 10 amperes, zero to 5 amperes, or zero to 1 ampere will all use the same meter movement (or scale). This same scale movement is achieved through the use of different values of shunt resistance with the meter. The designer of the ammeter simply calculates the correct shunt resistance required to extend the range of the meter to measure any desired value of current. This shunt is then connected in parallel with the meter terminals. Shunts may be located inside the meter (internal shunts) with front-panel switches provided to select them, or they may be located outside the meter (external shunts) with the necessary leads to connect them to the meter. External shunts are generally used where currents greater than 50 amperes must be measured.

It is important to select a suitable shunt when an external shunt ammeter is used so that the scale deflection is easily read. For example, if the scale has 150 divisions and the load current to be measured is known to be between 50 and 100 amperes, a 150 ampere shunt


SCALE CALIBRATED IN AMPERES
TO REAR BALANCE SPRING
D'ARSONVAL MOVEMENT
N
S
FROM REAR BALANCE SPRING
METER LEADS
EXTERNAL SHUNT
VOLTAGE SOURCE FOR LOAD
LOAD

(A) INTERNAL CONSTRUCTION & CIRCUIT

(B) EXTERNAL VIEW


SHUNT STRIPS
COPPER BLOCKS

(C) TYPICAL EXTERNAL AMMETER SHUNTS

5.107:.110

Figure 7-3.—Coil placed between tow magnetic poles, giving basic "D'ARSONVAL MOVEMENT".

is suitable. Under these conditions, each division of the scale will represent 1 ampere. A full-scale deflection of the pointer would indicate that 150 amperes of current is flowing. A half-scale deflection would indicate that 75 amperes of current is flowing. If a shunt of too low an ohmic value is selected, it is possible for higher than normal load currents to drive the pointer off scale and damage the meter movement mechanisms.

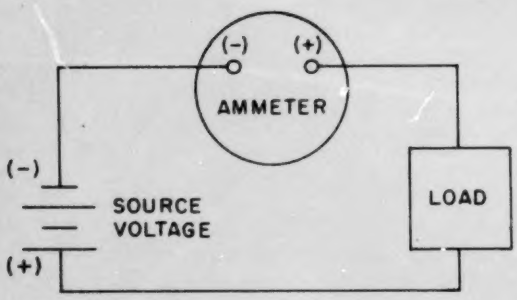
As pointed out earlier, current measuring instruments must always be connected in series with the circuit under test. If an ammeter were connected in parallel with a circuit under test, the source voltage (or close to it) would be applied directly to the meter terminals. This is because the low internal resistance of the meter bypasses the effective circuit resistance, resulting in excessive current through the meter, possibly damaging the meter beyond repair.

If the approximate value of current to be measured is not known, it is best to start with the highest range of the ammeter and switch to progressively lower ranges until a suitable reading is obtained.

Most ammeter needles indicate the magnitude of the current with a left-to-right meter deflection on the scale. However, if the meter is connected with reverse polarity, the needle will be deflected backward and the meter may be damaged. Therefore, it is important that the proper polarity of terminal hook-up be observed when an ammeter is connected into a circuit to be tested. That is, the meter should always be connected so that the current flow is into the negative (-) terminal and out of the positive (+) terminal (as shown in figure 7-4).

METER SENSITIVITY is a term referring to the amount of current necessary to produce full-scale deflection of the pointer. The smaller the current required to produce this deflection, the better the sensitivity of the meter. Thus, a meter movement which required only 1 ampere for full scale deflection would have a better sensitivity than a meter movement which requires 2 amperes for the same deflection.

Good meter sensitivity is especially important in ammeters which are to be used in circuits where small currents are flowing. As the meter is connected in series with the circuit under test, the current flows through the meter. If the internal resistance of the meter adds significantly to the load resistance, a meter LOADING EFFECT will occur. Meter loading is defined as "the condition which exists when the insertion of a meter into a circuit changes the operation of that circuit." This condition is not desired. When a meter is inserted into a circuit, its use is intended to allow the measurement of circuit current in the normal operating condition.



76.109

Figure 7-4.—Proper polarity must be observed when connecting ammeters into a circuit.

Voltmeters

Voltage measuring instruments are connected in parallel with (across) a circuit under test. If the voltage to be measured is not known, it is best to start with the highest range of the voltmeter and progressively lower the range until a suitable reading is obtained. As with the ammeter, the voltmeter is connected so that current will flow into the negative terminal of the meter.

The function of a voltmeter is to indicate the potential difference between two points in a circuit. Unlike ammeters, the voltmeter should have as high an internal resistance as practicable. If the voltmeter has a low resistance, it will draw an appreciable amount of current. As you recall, this shunting happens because overall circuit resistance decreases when placed in parallel, and the circuit current will divide accordingly along the parallel paths. Therefore, the effective resistance of the circuit under test is lowered and the voltage reading between two points will be changed.

Whenever voltage measurements are made in high-resistance circuits, it is necessary to use a high resistance voltmeter to prevent this "shunting" action of the meter. The effect is less noticeable in low-resistance circuits because the shunting effect is less.

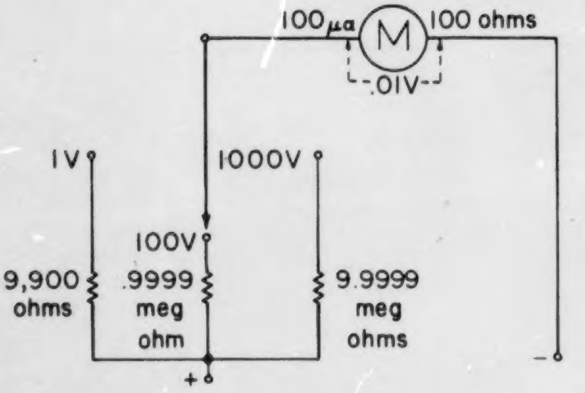
The D'Arsonval meter movement, used in ammeters, may also be used to measure voltage. It must be remembered that the D'Arsonval movement utilizes current flow to produce a magnetic field which is proportional to the current. This meter movement is an indicator of current flow rather than voltage. However, the addition of a series resistance allows the meter to be calibrated in terms of voltage. It still operates because of the current flow through the meter, but the scale may be marked off in volts.

An ohms-per-volt rating usually attracts your attention when dealing with voltmeters. The ohms-per-volt rating designates the amount of resistance that must be connected in series with the meter to produce full-scale deflection with only 1 volt applied to its terminals. The two most commonly used ohms-per-volt ratings for voltmeters used in the Navy are the 1000 and 20,000 ohms-per-volt ratings. This rating is referred to as the meter sensitivity.

The accuracy of a voltmeter, or any meter, is generally expressed in percent. For example, a meter that has an accuracy of 1 percent of the correct value means that if the correct value is 100 units, the meter indication may be anywhere within the range of 99 to 101 units.

Multirange voltmeters utilize one meter scale with the required resistances connected in series with the meter by front-panel switches located on the case of the meter. A schematic diagram of a multirange voltmeter with three ranges is shown in figure 7-5. The schematically represented resistors are located inside the meter and are selected with a front-panel control. As is seen, the voltage range being measured (1V, 100V, 1000V), determines which series resistance is selected. Thus, the correct reading is indicated on the voltmeter and the meter itself is protected from excessive current. In some voltmeters, for measuring higher voltages, the series resistance may be connected externally much like the ammeter.

The most important thing to remember when voltage measurements are calculated is the sensitivity of the voltmeter. As mentioned previously, a voltmeter should have as high a resistance as practicable with reference to the circuit under test. It is necessary to be able to calculate the shunting effect (or loading) of a circuit by a voltmeter. For example, if the sensitivity of a voltmeter is rated at 20,000 ohms-per-volt, and we are using the 10-volt range of the meter, the shunting resistance is 200,000 ohms (20,000 x 10). For technicians more than operators, this is an important piece of information to be able to calculate as part of quality assurance checks.



179.9
Figure 7-5.— Schematic diagram of a multi-range voltmeter.

One last thing to remember about voltmeters. Whenever you are making preventive or corrective checks, work with one hand only when inserting the test probes into output jacks or when making contact with voltage points. It is desirable to be able to insert test probes into test output jacks and then energize the equipment. If this is not possible, then utilize the recommended safety precautions located at the end of this chapter. REMEMBER, by placing yourself across the test probes of the meter used, you are providing a path for current to flow from test point to test point through your body.

Ohmmeters

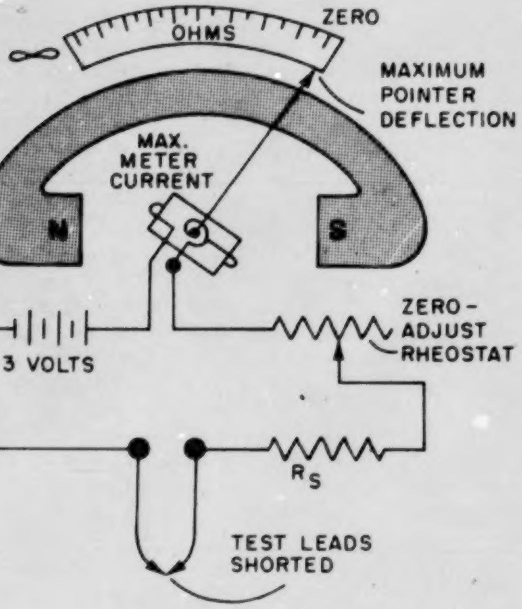
An ohmmeter is a direct-reading instrument for measuring resistance. Its scale is usually graduated in ohms, megohms, or both. If the scale is graduated in megohms, the instrument is called a megohmmeter; if the scale is calibrated in kilohms, the instrument is a kilohmmeter.

The ohmmeter is widely used to measure resistance and check the continuity of electrical circuits and devices. Its range usually extends to only a few megohms. The megohmmeter (discussed later) is widely used for measuring insulation resistance, such as between a wire and the outer surface of its insulation. The range of a megger may be extended to more than 1000 megohms.

The ohmmeter actually consists of an ammeter, which was discussed earlier, with a few added features. The added features are:

1. A d.c. source of potential.
2. One or more resistors (one of which is variable).

A simple ohmmeter circuit is shown in figure 7-6. The d.c. source of potential is a simple battery. The resistor is a zero-adjust rheostat



179.11

Figure 7-6.—Simple Ohmmeter circuit.

in series with the meter and battery. The zero adjust is normally a front-panel control located on the meter case.

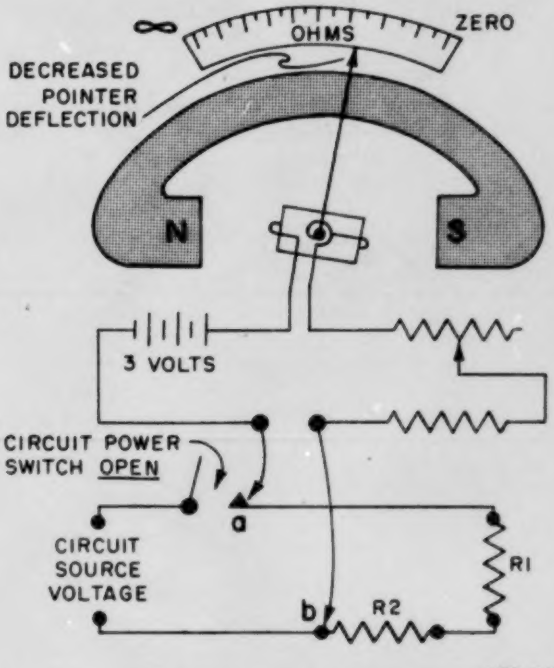
The ohmmeter's pointer deflection is controlled by the amount of battery current passing through the coil located at the base of the pointer (D'Arsonval meter movement). The zero-adjust rheostat, controlled from the front-panel, is used to zero the meter and to compensate for the natural aging of the d.c. battery.

To calibrate the ohmmeter (make it ready for use), first short the test leads together as shown in figure 7-6. With the test leads shorted, there will be a complete series circuit consisting of the 3 volt d.c. source, the resistance of the meter coil, the resistance of the zero-adjust rheostat, and the series multiplying resistor, Rs. Current will flow from the battery, and the meter pointer will be deflected. With the test leads shorted, the zero-adjust rheostat is set so that the pointer rests on the zero mark. Therefore, full-scale deflection indicates zero resistance between the test leads. Notice that the zero setting on ohmmeters is on the far right-hand side of the graduated scale. In most meters, the opposite is true.

If the range is changed, the meter must be "zeroed" again to obtain an accurate reading. When the test leads of an ohmmeter are separated, the pointer of the meter will return to the left side of the scale due to the spring tension acting on the base of the pointer. This reading indicates an infinite resistance.

If the value of resistance to be measured can be estimated within reasonable limits, a range should be selected which will give approximately half-scale deflection when this resistance is inserted between the two test probes. If the resistance is unknown, the range selector switch should be set on the highest meter scale. Whatever range is selected, the meter must be calibrated to read zero before the resistance is measured.

After the ohmmeter is adjusted for zero reading, it is ready to be connected into a circuit and measure resistance. A typical circuit and ohmmeter arrangement is shown in figure 7-7. The power switch of the circuit to be measured should always be in the OFF



179.12

Figure 7-7.—Typical ohmmeter arrangement in a circuit under test.

position. This prevents the circuit's source voltage from being applied across the meter, which could damage or ruin it.

As the ohmmeter is an open circuit when the test leads are separated, a path for the meter's battery current must be completed through the resistance to be measured. In figure 7-7, this is accomplished by connecting the meter at points a and b. This places the resistors R1 and R2 in series with the meter coil, zero-rheostat, and multiplying resistor. Since the meter has been preadjusted (zeroed), the amount of meter deflection now depends solely on the resistance of R1 and R2. The pointer will now come to rest at a scale figure indicating the combined resistance of R1 and R2. The scale reading of the meter, in ohms, is inversely proportional to current flow in the moving coil. In other words, as we increase the resistance measured, we decrease the current flow through the coil at the base of the pointer, thereby decreasing meter deflection. The pointer starts at the far left-hand part of the scale and proceeds to the right towards zero. The higher the resistance measured, the less the pointer will move because the higher values of resistance are located at the far left-hand side. As we measure less resistance, the pointer moves further towards zero, or no resistance.

The amount of circuit resistance to be measured may vary over a wide range. In some cases it may be only a few ohms, and in other cases it may be as great as 1 megohm. To enable the meter to indicate any value being measured with the least error, scale multiplication features are incorporated into most ohmmeters. Most ohmmeters are equipped with a selector switch for selecting the multiplication scale desired.

A typical multiplication scale would read as follows on a meter front-panel: R X 1, R X 10, R X 100, R X 1000, R X 10,000 and R X 100,000. Let us assume that an ohmmeter is calibrated in divisions from zero to 1000 and we are using the R X 10 scale. After completing the path with the test probes, the pointer indicates 375 ohms of resistance. This would indicate an actual resistance of 3,750 ohms (375 X 10).

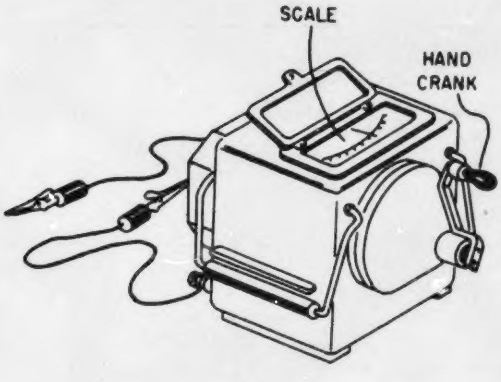
It always takes the same amount of current to deflect the pointer to a certain position on the scale. All that we are doing with the multiplying resistors is placing them in series with the rest of the meter circuit and the circuit under test to allow us to use one meter for more than one range. The operator of the ohmmeter should select the range that will result in the pointer coming to rest as near midpoint of the scale as possible. This enables the operator to read the resistance more accurately because the scale readings are more easily interpreted at or near mid-scale.

Megohmmeter (Megger)

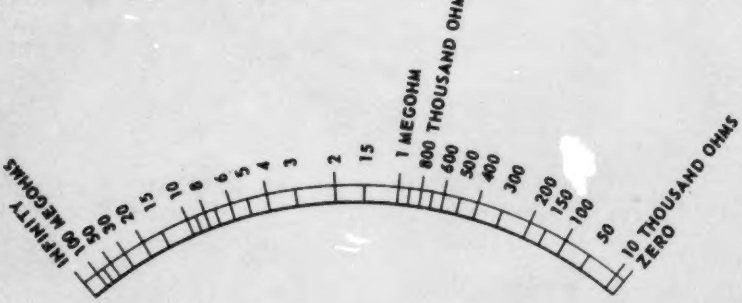
A megger is a high-range ohmmeter used for measuring high resistances. It is primarily an instrument that applies a high voltage to the component under test and measures the current leakage of the insulation. Thus, a capacitor or an insulated cable may be checked for leakage under much higher voltages than an ohmmeter is capable of supplying.

The megger is a portable instrument consisting of two primary elements: (1) a hand driven d.c. generator which supplies the necessary voltage for making the measurement, and (2) the instrument portion which has a scale indicating the value of the resistance being measured. Figure 7-8 shows an external view of a typical megger with associated hand crank and read-out scale. The name "megger" is derived from the fact that it measures resistances of many megohms.

There are various resistance ratings of meggers, some with scale values as low as 5 megohms and some with scales as high as 10,000 megohms. Figure 7-9 shows the scale of a 100-megohms, 500-volt megger. It could very well



1.55
Figure 7-8.—External view of a typical "Megger".



12.255

Figure 7-9.—Scale of a 100-Megohm megger.

be the scale of the megger shown in figure 7-8. Notice that the scale graduates in divisions from right-to-left. At the far left-hand side of the scale is "INFINITY". A reading of infinity means that the resistance being measured is infinite, or too great to be measured. That would mean that the resistance reading is greater than 100 megohms which is the highest division on the scale. The highest division on a megger scale is usually of one immediately below and to the right of the "infinity" reading. This figure represents the highest figure for which the instrument can be accurately used.

There are various voltage ratings of meggers, (100, 500, 750, 1,000, 2,500, etc.). The most common type is the one with the 500-volt rating. This voltage rating refers to the maximum output voltage of the megger. This voltage is supplied by the hand crank located on the external case of the megger, as shown in figure 7-8. To avoid excessive voltages, most meggers are equipped with friction clutches. Whenever the generator is cranked faster than its rated speed, the clutch slips, and the generator output voltage is not allowed to exceed its rated limit.

Meggers are used to test the insulation resistance of conductors and RF cables as well as the dielectric strength of capacitors. In other words, every conductor or cable has a certain current and voltage rating that it is supposed to be able to withstand without self-destructing or "burning out". By properly placing the test probes of the megger to the component under test, we can insert that amount of voltage at a particular current value. The read-out on the scale will indicate a certain amount of resistance in megohms as we turn the hand crank of the megger. We can compare this reading with the rating of the component and determine whether the component is weakening with age and should be replaced or not. This is an especially important check for RF transmission lines between transmitters and antennas.

Some of the more common procedures and precautions for meggers are:

1. When a megger test is made, the equipment or component must not be energized. It must be disconnected entirely from the system before it is tested.

2. Observe all rules for safety in preparing equipment for test and in testing, especially when testing high voltage apparatus.

3. Use well-insulated test leads, especially when using high range meggers. Before connecting the test leads (probes) to the component to be tested, operate the megger and make sure there is no leakage between the leads. The reading should be infinity whenever the leads are connected to the megger and prior to testing. Touch the ends of the test leads together and turn the handcrank slowly. The reading should be approximately zero. This test ensures that the leads are not disconnected or broken.

4. When using meggers (especially high range meggers), take proper precautions against electrical shock. There is sufficient capacitance in

almost any electrical equipment to "store" a charge from the energy supplied by the megger generator. This stored energy can provide a dangerous electrical shock. This danger decreases when you are testing individual components, but is still present between elements of components.

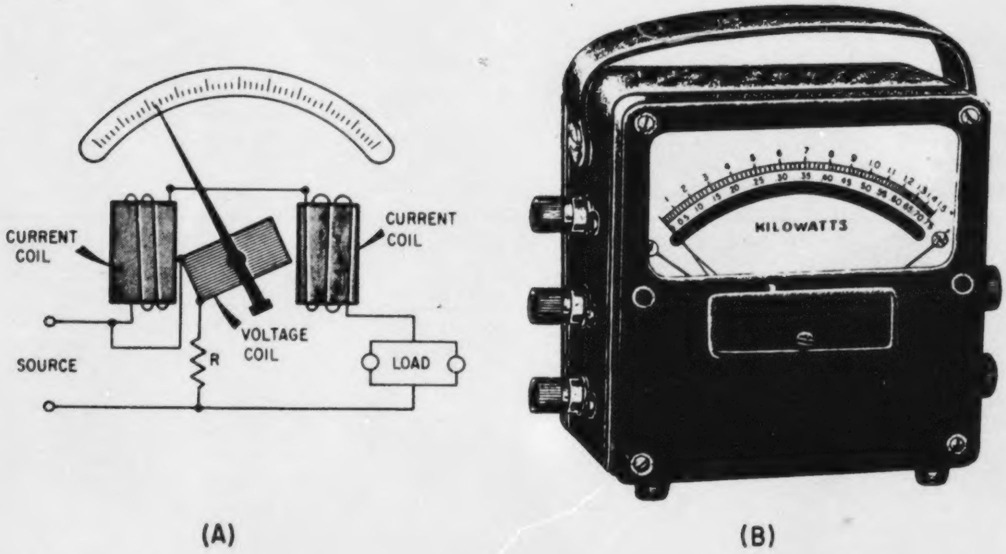
5. Equipment or components having considerable capacitance should be discharged before and after making megger tests.

Wattmeters

A wattmeter is an instrument used to measure the magnitude of active power in a circuit. Its scale is normally graduated in watts. If graduated in kilowatts or megawatts, it is usually designated as a kilowattmeter or megawattmeter. The most commonly used wattmeter is of the ELECTRODYNAMIC type, shown in figure 7-10. This type of wattmeter is used to measure power from either a.c. or d.c. sources.

Electrically speaking, "electrodynamic" means electricity in motion and the effects of magnetism and inductance. Referring to figure 7-10, we have two current coils, between which is a voltage coil with a pointer attached to it. The current coils are fixed; they do not move. As current flows through them, a magnetic flux field is formed between them proportionate to the amount of current flowing. This magnetic field induces a current in the voltage coil with the pointer attached. Consequently, the pointer indicates a scale value proportional to the values of line current and voltage. Since we are using electricity in motion as well as the effects of magnetism and inductance, the term "electrodynamic" properly describes the type of meter movement employed with the wattmeter.

Electrodynamic wattmeters are subject to errors arising from various factors, such as temperature and frequency characteristics. For example, heat through the coils will eventually cause the small springs attached to the pointer to lengthen and lose tension, producing deflection errors. Large currents within the wattmeter will also produce an appreciable error. This is due to the heat loss suffered through coils with high currents applied. Therefore, the maximum current range of electrodynamic wattmeters is normally restricted to approximately 20 amperes.



76.110

Figure 7-10.—Typical ELECTRODYNAMIC Wattmeter.

The voltage range of wattmeters is generally limited to several hundred volts because of heat dissipation within the voltage circuit. However, the voltage range can be extended by using external voltage multipliers, much like ammeters.

High-grade portable wattmeters have an accuracy of 0.2 to 0.25 percent. It must be remembered that electrodynamic wattmeter errors increase with frequency. For the higher frequency and power ranges, there are special types of wattmeters made specifically for those ranges.

An important point should be made about wattmeters: the reading of the pointer does not tell the user whether or not the internal coils of the meter are being overheated. If an ammeter or voltmeter is overloaded, the pointer will indicate beyond the upper limit of its scale. In the wattmeter, both the fixed and movable coil circuits may be carrying such an overload that their insulation is burning, yet the pointer may be only part way up the scale. Therefore, the "safe rating" for current and voltage should be strictly heeded. This safe rating is normally given on the face of the meter. If not, the information will be given in the technical manual for the meter. A wattmeter is always distinctly rated, not in watts, but in volts and amperes.

FREQUENCY MEASUREMENT

Frequency measurements are often an essential part of preventive and corrective maintenance. Equipment operating in the af and RF ranges must often be adjusted to operate at the correct frequencies. Radio transmitters must be accurately tuned to the assigned frequencies to provide reliable communications and avoid interfering with radio circuits operating on other frequencies.

Frequency measuring equipment constitute a distinct class of test equipment because of the important and critical nature of such measurements.

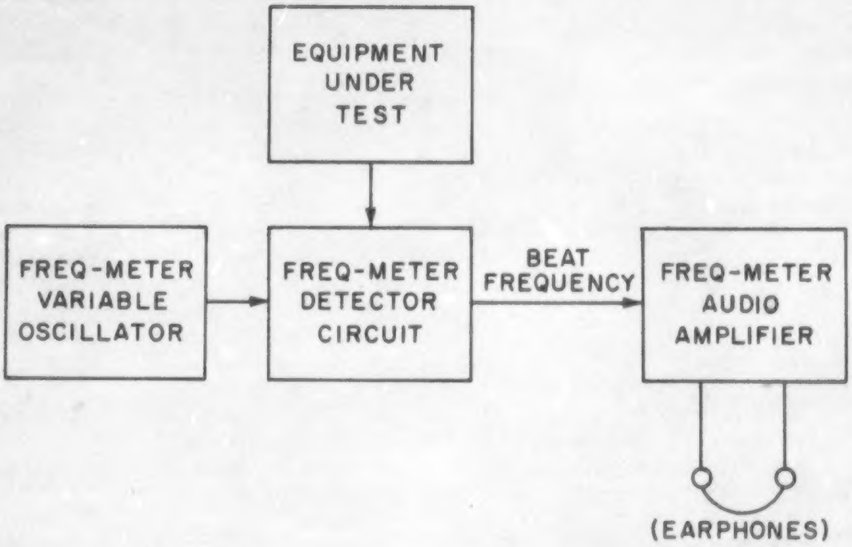
Heterodyne Frequency Meters

Reliable meters for measuring radio frequencies are heterodyne frequency meters. They measure the frequency of the unknown RF signal by matching the unknown signal with a locally generated signal of the same frequency obtained from a calibrated, high precision oscillator. This method is normally referred to as "zero-beating". When perfect frequency match is obtained, it is indicated by the absence of a beat note (zero beat). The zero-beat indicator in test equipment of this type is generally a pair of headphones.

The basic heterodyne meter (see figure 7-11) is a calibrated variable oscillator with associated circuits which heterodynes against the frequency to be measured. Coupling is made between the frequency meter and the output of the equipment under test, (this coupling should be in accordance with the step-by-step procedures listed in the technical manual for the frequency meter). The calibrated oscillator is then tuned so that the difference between the oscillator frequency and the unknown frequency is in the af range. This difference in frequency is known as the beat frequency. As the two frequencies are brought closer to the same value, the tone in the headset will decrease in pitch until it is replaced by a series of rapid clicks. As the process is continued, the clicks decrease in rapidity until they stop altogether. This is the point of zero beat (see figure 7-12) where the frequency generated in the oscillator of the frequency meter is equal to the frequency of the unknown signal being measured. For all practical purposes, the point of zero beat can be assumed when the clicks are heard at an infrequent interval. It is extremely difficult to maintain a condition of absolute silence when you are making this measurement. When the incoming signal is fairly strong, the clicks are sharp and distinct. When the signal is weak, the zero beat condition is evidenced by a slowly changing swishing or rushing sound in the headset. After the zero beat is obtained, the dial reading corresponds to the frequency under measurement.

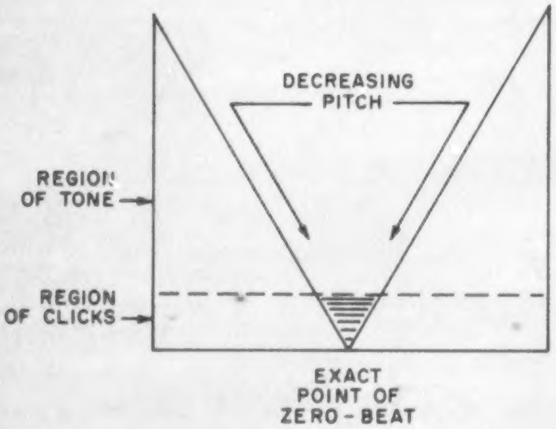
The calibration book is a very important part of the frequency meter; in fact, the book is so important that it bears the same serial number as the heterodyne frequency meter itself. Contained in this book is a list of the dial settings and the corresponding frequencies produced by the meter at those dial settings. Concise operating instructions for the meter are also included.

The general accuracy of the audible zero beat method is in the range of 0.04 to 0.02


EQUIPMENT UNDER TEST
FREQ-METER VARIABLE OSCILLATOR
FREQ-METER DETECTOR CIRCUIT
BEAT FREQUENCY
FREQ-METER AUDIO AMPLIFIER
(EARPHONES)

76.111

Figure 7-11.—Usage of basic heterodyne frequency meter.



76.112

Figure 7-12.—Graph of sound observed in earphones when zero-beating.

percent. There are many things that can affect the accuracy of a frequency meter and produce errors. Mechanical action, such as small shocks, thrust exerted on the main tuning control during operation, and the action of locking the dials, can produce errors ranging from 30 to 200 hertz. Variations in antenna loading, calibration, frequency drift, and warm-up periods may also cause measuring errors. Particular attention should be paid to frequency meter warm-up time. During the warm-up period, the beat note will drift, becoming a steady tone when the proper operating temperature is reached.

Several operational considerations for frequency meters are:

1. Know the condition of the batteries located in the power supply prior to use.

2. Exercise extreme care in operating the frequency setting controls.

3. Do not be hasty when obtaining a zero beat. Look for the correct beat note, and obtain the best null possible.

FREQUENCY STANDARDS

The requirement of precise calibration is extremely important in all frequency measuring work. In order to provide accurate measurements, every type of frequency meter must be calibrated against some frequency standard at least once weekly. Of considerable importance in the measurements of frequency are the standards against which frequency meters are compared and calibrated.

Frequency standards are either primary or secondary. The primary frequency standard maintained by the U.S. Bureau of Standards has long-term stability and accuracy. A secondary frequency standard is a highly stable and accurate standard that has been calibrated against the primary standard.

U.S. National Bureau of Standards

The National Bureau of Standards provides time and frequency standards from station WWV at Beltsville, Maryland, and from station WWVH at Maui, Hawaii. These two stations provide the following technical radio services and are given continuously:

Standard radio frequencies
Standard audio frequencies
Standard time intervals
Standard musical pitch
Time signals
Radio propagation notices

Radio Frequencies

To ensure reliable coverage of the U.S.A. and extensive coverage of the world, radio stations WWV and WWVH provide the following standard radio frequencies in MHz:

Station WWV	Station WWVH
2.5, 5, 10, 15, 20	5, 10, and 15

Audio Frequencies and Musical Pitch

Two standard audio frequency tones, 440 and 600 hertz, are broadcast on all WWV and WWVH radio carrier frequencies.

The audio frequency tones for WWV are given alternately, starting with the 600 hertz on the hour for three minutes. There is a pause, with no audio frequency available for two minutes. At the end of the two minute pause, the 440 hertz tone is broadcast for two minutes. At the end of two minutes, there is a three minute pause. The total time period expended is ten minutes. At the end of that ten minute period, the process begins all over again with the 600 hertz tone. Each ten-minute interval in the hour is repeated. These audio frequencies are transmitted by WWVH in the same manner.

The 440 hertz tone is the standard musical pitch: A above middle C. The 600 hertz tone provides a frequency standard for use in checking the 60 hertz power line frequency.

Time Intervals and Signals

The standard time pulse of WWV is 100 hertz. The standard time pulse of WWVH is 1200 hertz. These marker pulses are heard as ticks. Intervals of one minute are marked by the omission of the pulse at the beginning of the last second of every minute, and commencing on the minute.

Universal Time information is transmitted from WWV and WWVH. WWV transmits Universal time in telegraphic code, and Eastern Standard Time by a voice announcement. The code is transmitted during the 1-minute interval following each 2-minute tone transmission. Specifically, you will hear 2-minutes of tone. At the end of two minutes, the tone will cease and there will be a 1-minute interval before the tone begins again. During the last 20-seconds of the 1-minute interval, Universal time will be transmitted via telegraphic code and Eastern Standard Time via voice. At WWVH, Universal Time is announced by telegraphic code before each tone transmission.

Radio Propagation Forecasts

An announcement of radio propagation conditions for the North Atlantic area is broadcast by station WWV in telegraphic code on each of the standard radio frequencies at 19.5 and 49.5 minutes past each hour. Forecasts from WWVH for the North Pacific area are given at 9.4 and 39.4 minutes past each hour.

These notices, transmitted in International Morse Code, consist of a letter followed by a digit. The letter designations N, U, and W, signifying "normal", "unsettled", and "disturbed", respectively, classify the radio propagation conditions at the time of the broadcast. The digits from 1 to 9 indicate the expected radio propagation conditions for the next twelve hours. The National Bureau of Standards forecasts are based on information obtained from a worldwide network of geophysical and solar observations. The code interpretations for propagation conditions are contained in table 7-1.

TABLE 7-1

NBS RADIO PROPAGATION CODING

DIGIT (Forecast)	PROPAGATION CONDITION
1	Impossible
2	Very Poor
3	Poor
4	Fair to Poor
5	Fair
6	Fair to Good
7	Good
8	Very Good
9	Excellent

Therefore, a transmission of "N5" would mean that the propagation conditions at the time of the broadcast are "normal" and the propagation conditions for the next 12 hours would be "Fair".

Secondary Standards

A secondary frequency standard, much like a piece of test equipment, is normally kept in the operating spaces of a communications center as well as in equipment repair shops afloat and ashore. They are normally no more than highly stable oscillators contained inside an equipment case with front-panel operating controls, and they generate a variety of frequencies with which to compare your frequency meters and transmitters. These oscillators normally operate in the frequency range between 25 and 1000 kHz.

The accuracy of a secondary frequency standard is maintained only when periodic calibration checks are made against a primary standard or against standard frequency transmissions of WWV or WWVH. These transmissions are broadcast continuously and are monitored with the National Primary Frequency Standard, which is maintained at the Bureau Of Standards, Washington, D.C.

Silent Periods

The WWV transmissions are interrupted for approximately four minutes each hour. The silent period commences at 45 minutes after each hour. The WWVH transmissions are interrupted for four minutes following each hour on the hour and at each half-hour past the hour. WWVH transmissions are also interrupted each day at 1900Z for a period of 34 minutes.

FREQUENCY GENERATORS

Frequency generators (sometimes called signal generators) are test devices that generate or produce an a.c. signal that is suitable for test purposes. In effect, they are small radio transmitters which can be constructed to generate a signal of any desired frequency within its frequency range. This generated signal may be modulated or unmodulated and is normally used for the following tests or checks associated with communications equipment:

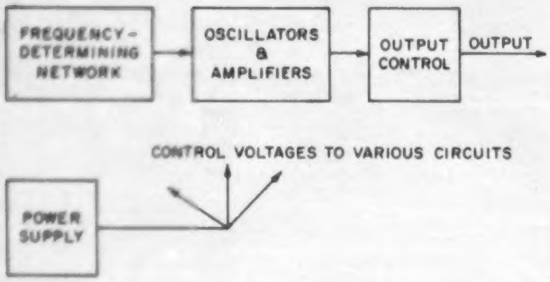
1. Circuit alignment
2. Sensitivity measurements
3. Field-intensity measurements
4. Approximate frequency measurements
5. Corrective maintenance (signal-tracing)

Their use as a device for making approximate frequency measurements is limited. This is because the signal generator is not a frequency meter and cannot be relied upon as a frequency standard. Signal generators are used primarily in the alignment of equipment circuits.

Frequency generators, classified according to frequency, are of two types: audio frequency and radio frequency.

Audio Frequency Generators

Audio frequency generators, which are sometimes called audio oscillators, are capable of producing frequencies from 20 to 200,000 hertz. They are used primarily for testing audio sections of communications equipment. The major components of an audio signal generator are a frequency-determining network, an oscillator (or oscillators), one or more amplifiers, an output control, and a power supply. (See figure 7-13.)


FREQUENCY-DETERMINING NETWORK
OSCILLATORS & AMPLIFIERS
OUTPUT CONTROL
OUTPUT
CONTROL VOLTAGES TO VARIOUS CIRCUITS
POWER SUPPLY

76.113

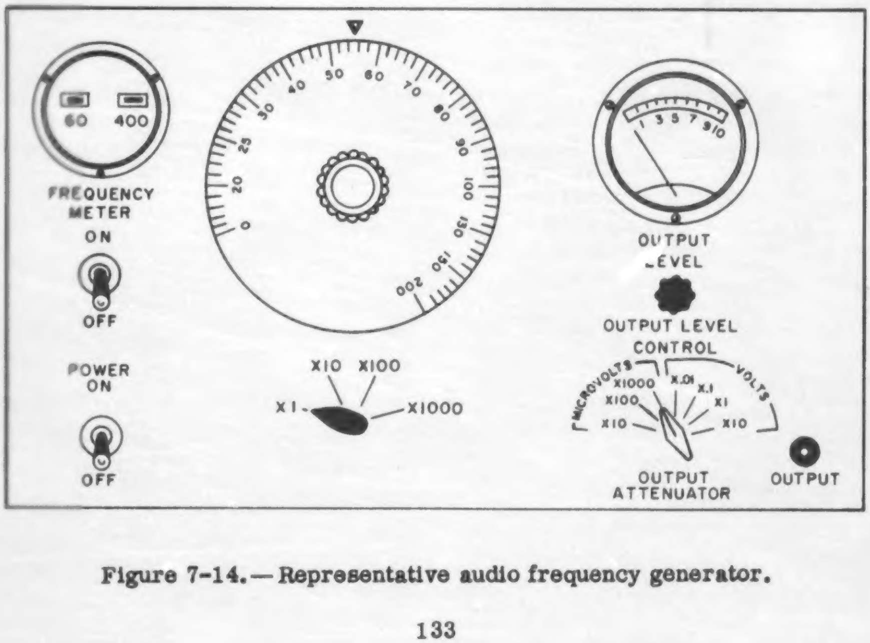
Figure 7-13.—Major components of an audio signal generator.

A representative audio frequency generator is shown in figure 7-14. Operating from the line voltage of 115 volts a.c., it produces output frequencies in conjunction with a four-position multiplier. Any frequency from 20 - 200,000 Hz may be selected by setting the main tuning dial and the range switch so that the two readings, when multiplied together, equal the desired frequency. For example, to select an output frequency of 52,000 Hz, the main tuning dial would be set to "52" and the range switch to "X1000".

Normally, frequencies must be generated at a particular voltage level to be inserted into a piece of equipment under preventive or corrective test. This is achieved through the "OUTPUT LEVEL" control in conjunction with the "OUTPUT ATTENUATOR". Voltages may be varied from 0 to 10 volts, as shown in figure 7-14. For intermediate values of output voltage, the "OUTPUT LEVEL" control is varied so that the output meter reads the desired voltage. The attenuator switch is then set so that its value, multiplied by the output meter reading, gives the desired output voltage level. For example, to obtain an output voltage of 0.04 volts, set the meter at 4 and the attenuator switch to the "0.01" position. The output voltage level of the generated signal will then be 0.04 volts (meter reading multiplied by the attenuator setting).

There are two frequency check points provided on the front panel of the signal generator. These check points are at 60 and 400 hertz. Basically, they check the calibration of the oscillator (or oscillators) inside the generator.

To check the operation of the oscillator at 60 hertz, set the main tuning dial to "60" and the range switch immediately below it to "XI". This sets the frequency of the oscillator to 60


60
400
FREQUENCY METER
ON
OFF
POWER ON
OFF
0
20
25
30
40
50
60
70
80
90
100
120
150
200
X1
X10
X100
X1000
1 3 5 7 9 10
OUTPUT LEVEL
OUTPUT LEVEL CONTROL
MICROVOLTS
VOLTS
X1000
X100
X10
X.01
X.1
X1
X10
OUTPUT ATTENUATOR
OUTPUT

179.17

Figure 7-14.—Representative audio frequency generator.

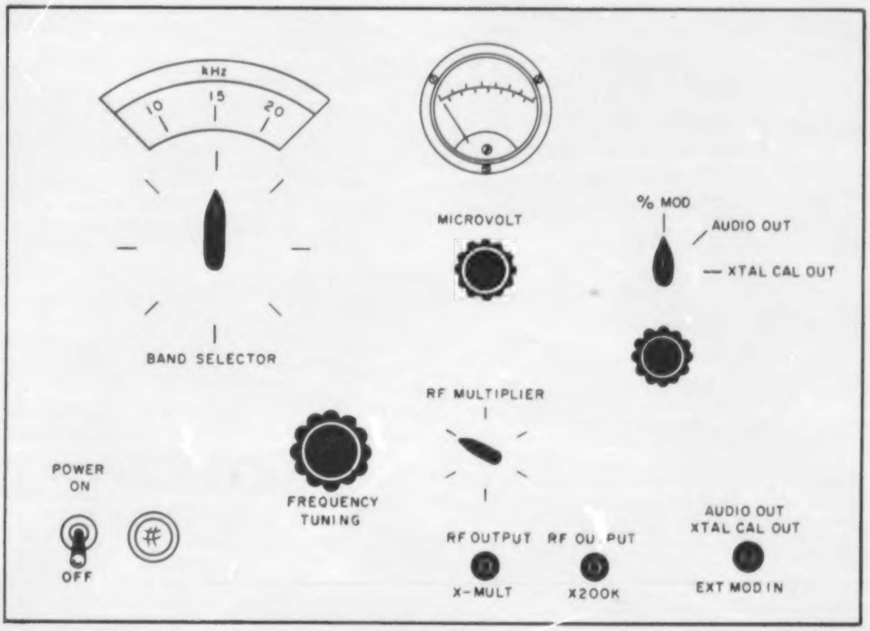
Hz. Turn the "FREQUENCY METER" switch on and move the main dial back and forth slightly until the 60 Hz reed (located upper left on the meter, figure 7-14) vibrates with maximum amplitude. The main tuning dial should indicate "60", within one division, if the frequency calibration is correct. Similarly, the output frequency may be checked at 400 Hz, by means of the 400 Hz reed on the frequency meter.

Radio Frequency Generators

Signal generators that cover the frequency range from about 10 kHz to 4.5 GHz are classified as RF signal generators. Figure 7-15 is a representative RF signal generator. Although the frequency range of RF generators may vary, the front-panel operating controls are generally standard.

The generator shown in figure 7-15 is assumed to have an output frequency range of 10 kHz to 50 MHz. It operates from a standard 115 v.a.c. outlet and produces its frequencies in 8 bands. The "BAND SELECTOR" is shown on the front panel of figure 7-15. The "MICROVOLT" and "MULTIPLIER" switches serve the same purpose as they did for the AF signal generator; by multiplying the microvolt meter reading and the position of the multiplier switch, we know the voltage level of the selected output signal at the "X-MULT" jack on the front panel. The output at the "X200K" jack is controlled only by the meter microvolt control knob. Every reading of the microvolt meter is multiplied by 200,000 in order to determine the output of the signal generator when this output jack is used. When this jack is used, the multiplier switch is not used.

Often, RF generator outputs are modulated. This modulation, usually an AF signal, is inserted at the "EXT MOD IN" jack on the lower right-hand side of the front panel. The voltage level at which this signal is inserted is normally controlled with the variable knob located immediately below the "% MOD" switch. The percentage of modulation is read from the lower scale of the "MICROVOLT" meter. There are several capabilities available to an operator of



179.18

Figure 7-15.—Representative RF signal generator.

this generator using these two controls. Because operating procedures often vary for these two controls, none are repeated here. For proper operation of the modulation jack and controls, refer to the applicable technical manual or maintenance manual.

OSCILLOSCOPES

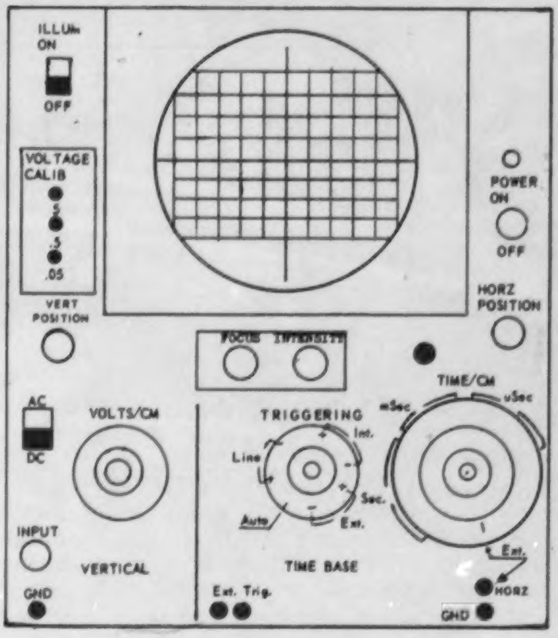
An oscilloscope is a piece of test equipment that gives a visual presentation of the measured signal on a front-panel screen, much like that contained in a television set. A typical basic oscilloscope is shown in figure 7-16. The "screen" is shown in the upper middle of the figure.

The oscilloscope, (sometimes called an "O-SCOPE") is the most versatile piece of test equipment that a technician has at his disposal. Most test equipment is designed to measure amplitude or quantity. The oscilloscope permits many characteristics of a circuit to be observed and measured. Some of these are:

1. Frequency.
2. Duration (or time) of one or more hertz.
3. Phase relationships between waveforms.
4. Shape of waveforms.
5. Amplitude of waveforms.

The oscilloscope may be used in preventive maintenance procedures for alignment of receivers and transmitters, frequency comparisons, percentage modulation checks, and equipment calibration.

A waveform may be considered as a pictorial representation of a varying signal. Distortion of a waveform is an undesired change or deviation in its shape. This is especially noticeable in amplifiers, when their components begin to deteriorate or break down in value. When this happens, the output waveform will change in amplitude, frequency, phase, etc. This change (or distortion) can be more readily detected with an oscilloscope as part of preventive or corrective checks. Naturally, the usefulness of an oscilloscope in any preventive or corrective technique depends upon the operator's knowledge of front-panel controls and operation, and how to interpret the resultant pictorial display on the screen.



1.86

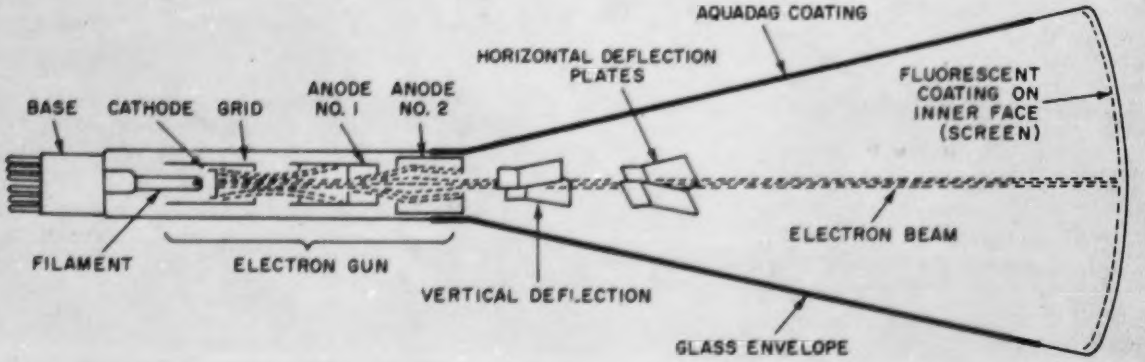
Figure 7-16.—Typical basic oscilloscope.

The Oscilloscope Screen

The screen observed on the front panel of an oscilloscope is actually the front of a CATHODE-RAY TUBE (CRT). For this reason, most oscilloscopes are called cathode-ray oscilloscopes (CROs). The CRT (shown in figure 7-17) is a special type of electron tube in which electrons emitted by a cathode are focused and accelerated to form a narrow beam having high velocity. The direction of this beam is then controlled and allowed to strike a fluorescent screen, whereupon light is emitted at the point of impact to produce a visual indication of the beam position. The electronic process of forming, focusing, accelerating, controlling, and deflecting the electron beam is accomplished by the following principal elements of the cathode-ray tube:

1. The electron-gun.
2. A fluorescent screen.

A simplified form of the electron gun, shown in figure 7-17, provides a concentrated beam of



76.114

Figure 7-17.—Basic Cathode-Ray Tube (CRT).

high-velocity electrons. The cathode, when properly heated, emits electrons. These electrons are attracted toward the accelerating and focusing anodes because of their high positive potential with respect to the cathode. In order to reach these anodes, the electrons are forced to pass through a cylindrical control grid, closed at one end except for a tiny circular opening, which concentrates the electrons and starts the formation of a beam. Electrons leaving this small aperture are strongly attracted by the positive potential on the focusing anode (anode No. 1) and accelerating anode (anode No. 2), which are also cylindrical in shape and have small openings to permit beam passage.

The electron beam is deflected after leaving the electron gun proper through the use of two pairs of parallel plates located on each side, above and below the beam. These plates, called the vertical and horizontal deflection plates, are oriented such that the electron beam must pass between them. If no electric potential exists between these two plates, the electron beam will continue moving forward and strike the screen at or near the center. If a source of potential is applied to one or both sets of plates, the electron beam will "veer", or be bent away, from the center of the screen. Therefore, the electron beam is shaped and accelerated by the electron gun and bent, or deflected, by the deflection plates.

In order to convert the energy of the electron beam into a visible light, that area where the beam strikes, the screen, is coated with a phosphor chemical, which, when bombarded by electrons, has the property of emitting light. This property is known as "fluorescence". The intensity of the lighted spot on the screen depends upon two factors:

1. The speed of the electrons in the beam, and

2. The number of electrons that strike the screen at a given point.

The amount of light per unit area which the phosphor is capable of emitting is limited, and once the maximum has been reached, any further increase in the electron bombardment has no further effect on the intensity of the light.

Oscilloscope Power Supplies

High-voltage and low-voltage power supplies are required for the operation of the oscilloscope. The high-voltage power supply is used to provide operating potentials to the cathode-ray tube. The low-voltage power supply is used to supply operating potentials to the associated oscilloscope circuitry, i.e.; amplifiers, oscillators, etc.

The output of the high-voltage power supply is usually over 1000 volts, d.c., depending upon the size of the cathode-ray tube. The output of the low-voltage power supply is usually in the 250 to 400 volt range.

Oscilloscope "Graticules"

Figure 7-16 shows a typical basic oscilloscope with square grid-work on the front of the screen. It is through this grid-work that we are able to accurately measure circuit outputs. This grid-work is normally detachable and can be replaced with a grid of different size squares in order to measure different quantities. These detachable grids are called "GRATICULES" and are normally provided on separate plates of glass or plastic that are accurately marked and can be mounted on the oscilloscope in front of the CRT.

Personnel Safety Precautions

You should never operate an oscilloscope with the case removed. High voltages that could cause fatal shock are exposed, and removal of the case reduces shielding of the instrument from stray external fields.

Extreme caution should be exercised when cathode-ray tubes are handled. The glass envelope encloses a high vacuum; undue stresses and tough handling can cause serious injury due to tube "implosion". The fluorescent coating of the cathode-ray tube is extremely toxic. When you are handling broken CRT's, avoid contact with this material.

Before using any oscilloscope, be completely familiar with the associated operating instructions. A lack of knowledge of operating instructions can lead to personal injury when you are using a piece of test equipment containing voltages as high as that of an oscilloscope. Always consult the oscilloscope technical manual for proper operation and applicable safety precautions.

SPECTRUM ANALYZERS

A spectrum analyzer is a device that sweeps over a band of frequencies to determine:

1. What frequencies are being produced by a specific circuit under test.
2. The amplitude of each frequency component.

To accomplish this, the spectrum analyzer presents on a self-contained CRT a pattern in which the relative amplitudes and frequencies can be plotted. Figure 7-18 shows the front panel of a typical spectrum analyzer. The CRT is shown in the upper left-hand corner of the front panel. An access door with an a.c. power receptacle and a wave-guide choke flange are shown on the side of the equipment. The wave-guide choke flange is used by electronics technicians and radar personnel and is not discussed here.

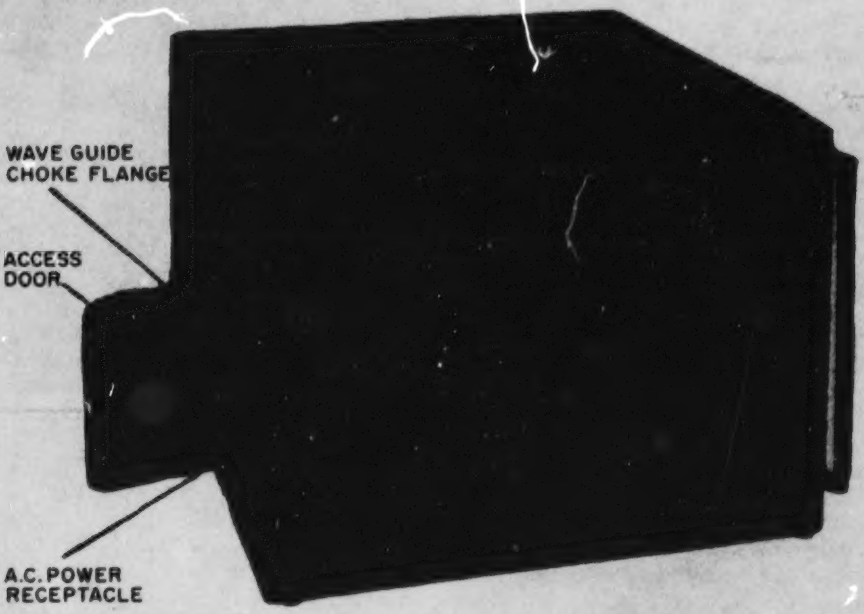
Basically, a spectrum analyzer consists of a superheterodyne receiver and frequency modulated RF oscillator (see figure 7-19). The RF oscillator beats with the incoming signal to produce an IF signal. This IF signal represents the various frequency components present in the spectrum of the received signal. These signals, after they are reduced to IF, are presented on the CRT as the spectrum pattern. Figure 7-20 is an example of a typical spectrum analyzer pattern. Here we see the basic frequency (or carrier) and its immediate, associated sidebands.

ELECTRON TUBE TESTERS

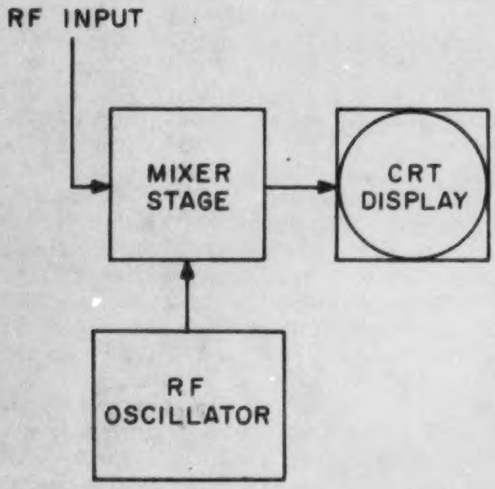
A number of different types of equipment have been developed for testing the condition of electron tubes. To be of practical use to the operator or technician in the field, a tube tester must provide a simple and quick appraisal of the quality of a tube. Therefore, checks made with field-type tube testers generally employ simplified methods.

Field-type tube testers like the TV-7/U (shown in figure 7-21) have certain limitations. Although they compare tube characteristics with a predetermined standard, they do not reveal how a tube will operate in a circuit under actual operating conditions. The final, and most accurate indication of the condition of an electron tube is its ability to function satisfactorily in the particular circuit where it is used. Many types of high-power tubes, such as those used in the PA section of transmitters, cannot be checked by general purpose tube testers because of impractical power requirements. These types of tubes must be checked in the equipment where they are used. However, field-type tube testers, although limited in the completeness of their tests, are very useful aids since they serve to check the condition of tubes most used in communication and electronic equipment.

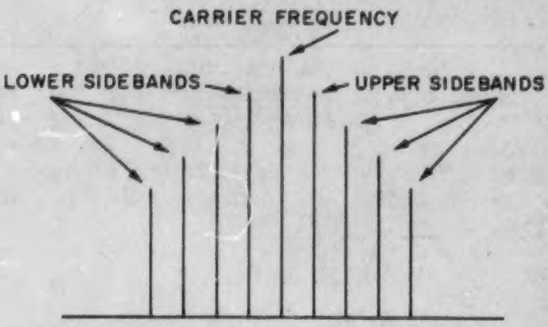
There are two different types of tube testers in common use in the field. These testers, which are distinguished by the main tube characteristic they check, are known as the emission type tester and the transconductance type tester. In addition to the main check, field-type tube testers may also be capable of performing short-circuit, noise, gas, and emission-leakage tests.


WAVE GUIDE CHOKE FLANGE
ACCESS DOOR
A.C. POWER RECEPTACLE

20.243
Figure 7-18.—Front-Panel of a typical spectrum analyzer.


RF INPUT
MIXER STAGE
CRT DISPLAY
RF OSCILLATOR

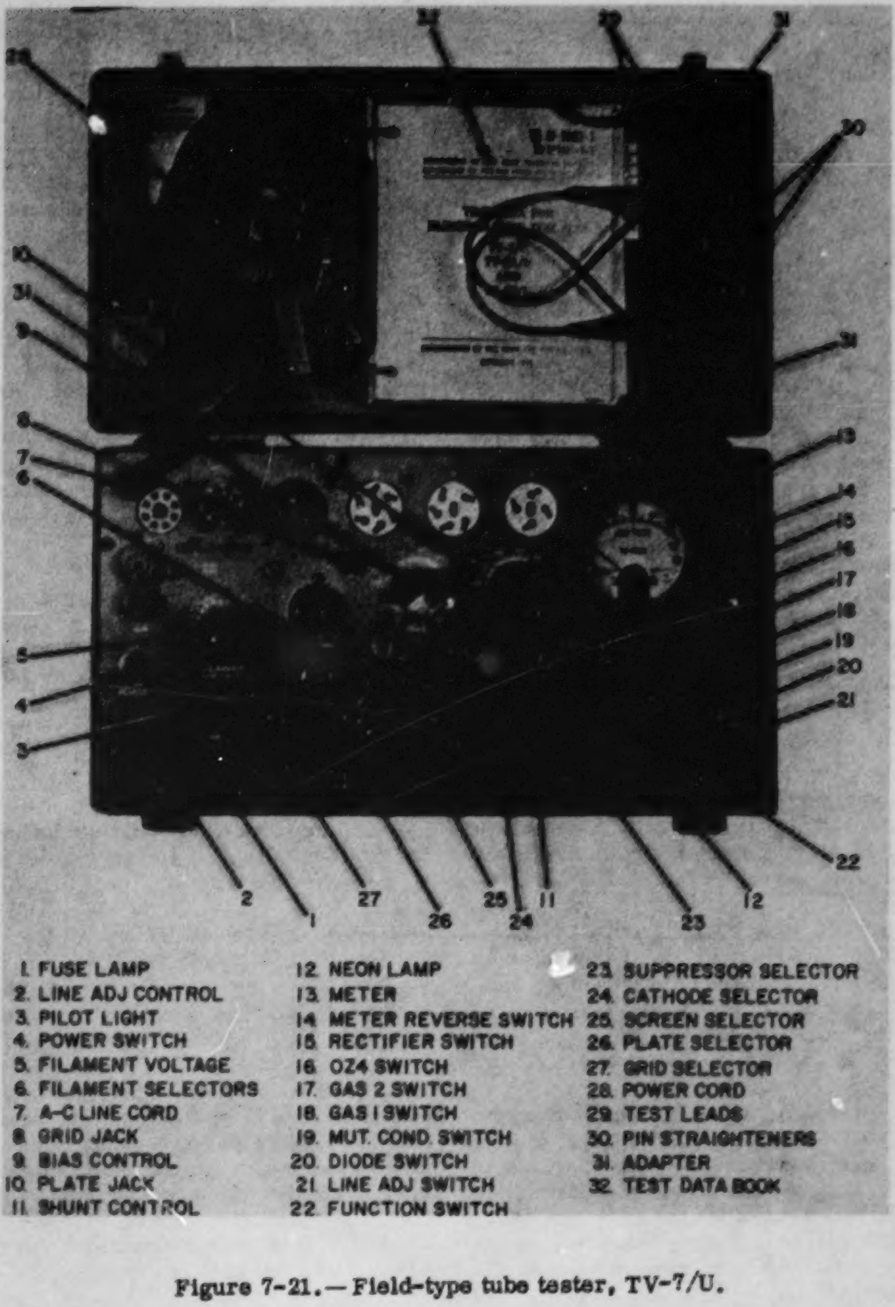
76.115
Figure 7-19.—Block diagram of basic spectrum analyzer.


CARRIER FREQUENCY
LOWER SIDEBANDS
UPPER SIDEBANDS

76.116
Figure 7-20.--Typical spectrum analyzer CRT display, showing carrier frequency and immediate sidebands.

Emission Testers

The emission type tube tester measures the condition of the emitting surface of the tube (known as the cathode). The end of the useful


1. FUSE LAMP
2. LINE ADJ CONTROL
3. PILOT LIGHT
4. POWER SWITCH
5. FILAMENT VOLTAGE
6. FILAMENT SELECTORS
7. A-C LINE CORD
8. GRID JACK
9. BIAS CONTROL
10. PLATE JACK
11. SHUNT CONTROL
12. NEON LAMP
13. METER
14. METER REVERSE SWITCH
15. RECTIFIER SWITCH
16. OZ4 SWITCH
17. GAS 2 SWITCH
18. GAS 1 SWITCH
19. MUT. COND. SWITCH
20. DIODE SWITCH
21. LINE ADJ SWITCH
22. FUNCTION SWITCH
23. SUPPRESSOR SELECTOR
24. CATHODE SELECTOR
25. SCREEN SELECTOR
26. PLATE SELECTOR
27. GRID SELECTOR
28. POWER CORD
29. TEST LEADS
30. PIN STRAIGHTENERS
31. ADAPTER
32. TEST DATA BOOK

20.346

Figure 7-21.—Field-type tube tester, TV-7/U.

life of a tube is usually preceded by a reduction in electron emission; that is, the cathode becomes unable to supply the number of electrons necessary for proper tube operation. Also, if the tube has an open element, the defect prevents proper emission, and the tester indicates it as a weak or bad tube.

Transconductance Testers

The transconductance type of tester provides a more accurate evaluation of the condition of a tube than the emission type because it measures the ability of the tube to amplify under simulated circuit conditions.

The term "transconductance" (also called mutual conductance) indicates the effect of control voltages upon the output current of a tube. After this is measured, the results are compared with the ratings of the tube manufacturer. The meter scale of this type of tube tester is normally calibrated to read GOOD, BAD, or WEAK. A voltage or power amplifier tube is considered defective when its transconductance value decreases to 70 percent of the value stated in the standard tube tables. An oscillator tube is considered defective when its transconductance decreases to 60 percent of table value.

ELECTRICAL SAFETY PRECAUTIONS

Every person who operates or repairs electronic equipment and test equipment should constantly be alert to the natural hazards and should also be capable of rendering aid to injured personnel.

Safety is a major responsibility of all persons. The installation, maintenance, and operation of electronic equipment enforces a stern safety code. Carelessness on the part of the operator or technician can result in serious injury or death due to shock, falls, burns, flying objects, etc.

After an electrical casualty has occurred, investigation almost invariably shows that it could have been prevented by the exercise of simple safety precautions and procedures that should be observed at all times. Each person concerned with electronic equipment should make it his responsibility to read and become thoroughly familiar with the safety practices and procedures contained in:

1. U.S. Navy Safety Practices (OPNAV-34PI).
2. BuShips Technical Manual (NAVSHIPS 250-000), Chapter 67.
3. NAVMED publication (P5056).
4. Electronic Installation and Maintenance Book (EIMB), NAVSHIPS 900,000.100.
5. Equipment Technical Manuals.

It is your responsibility to identify and eliminate unsafe conditions and unsafe acts which cause electrical casualties to personnel and equipment.

It must be borne in mind that de-energizing main supply circuits will not necessarily "kill" all circuits in a given piece of equipment. This is a common error of technicians and personnel making preventive maintenance checks and adjustments. In addition, aid to shock victims has often been hampered because of the time required to determine the sources of all inputs to equipments. Therefore, ensure ALL power inputs are off when the preventive or corrective procedure calls for it.

Take time to be safe when working on electronic circuits and equipment. Carefully study the entire system diagram, noting which circuits must be deenergized in addition to the main power supply. Power should be left on in equipment ONLY when necessary to the corrective or preventive check being made.

Remember that the 115-volt power supply voltage is not a low, relatively harmless voltage but is the voltage that has caused more deaths in the Navy than any other.

General Safety Practices

The following is a listing of common sense safety precautions that must be observed at all times:

1. DO NOT work with high voltage by yourself; have another person (safety observer), qualified in first aid for electrical shock, present at all times. The person stationed nearby should also know the circuits and switches controlling the equipment and should be given instructions to pull the switch immediately if anything unforeseen happens.

2. Always be aware of the nearness of high-voltage lines or circuits. Use rubber gloves where applicable, and stand on approved rubber matting (MIL-M-15562). Not all so-called rubber mats are good insulators.

3. Inform remote stations as to the circuit on which work is being performed.

4. Keep clothing, hands, and feet dry at all times if possible. When it is necessary to work in wet or damp locations, use a dry platform or wooden stool to sit or stand on, and place a rubber mat or other nonconductive material on top of the wood. Use insulated tools and insulated flashlights of the molded type when you are required to work on exposed parts.

5. DO NOT work on energized circuits unless absolutely necessary. Be sure to take time to lock out (or block out), or "tag-out" the main switch. Locks for this purpose should be readily available. If a lock cannot be obtained, remove the fuse and tag it.

6. Use one hand when turning switches ON or OFF. Keep the doors to switch and fuse boxes closed except when working inside or replacing fuses. Use a fuse puller to remove cartridge fuses, after first making certain that the circuit is dead.

7. All supply switches or cutout switches from which power could possibly be fed shall be secured in the OPEN (safety) position and tagged. The tag shall read "THIS CIRCUIT WAS ORDERED OPEN FOR REPAIRS AND SHALL NOT BE CLOSED EXCEPT BY DIRECT ORDER OF" (the person making, or directly in charge of repairs).

8. Never short out, tamper with, or block open an interlock switch.

9. Keep clear of exposed equipment; when it is necessary to work on it, use one hand as much as possible.

10. Avoid reaching into enclosures except when absolutely necessary; when reaching into an enclosure, use rubber blankets and rubber gloves.

11. Do not use bare hands to remove hot tubes from their circuit sockets. Use asbestos gloves or a tube puller.

12. Use a shorting probe to discharge all high-voltage capacitors.

13. Make certain that equipment is properly grounded. Ground all test equipment to the equipment under test.

14. When measuring circuits over 300 volts, do not hold the test prods (or probes).

Safety Shorting Probe

Always assume that there is a voltage present when working with circuits having high capacitance even when the circuit has been disconnected from its power source. Therefore, capacitors in such circuits should be discharged individually, using an approved type shorting probe. High capacity capacitors may retain their charge for a considerable period of time after having been disconnected from the power source. An approved type shorting probe is shown in figure 7-22.

Symptoms of Electrical Shock

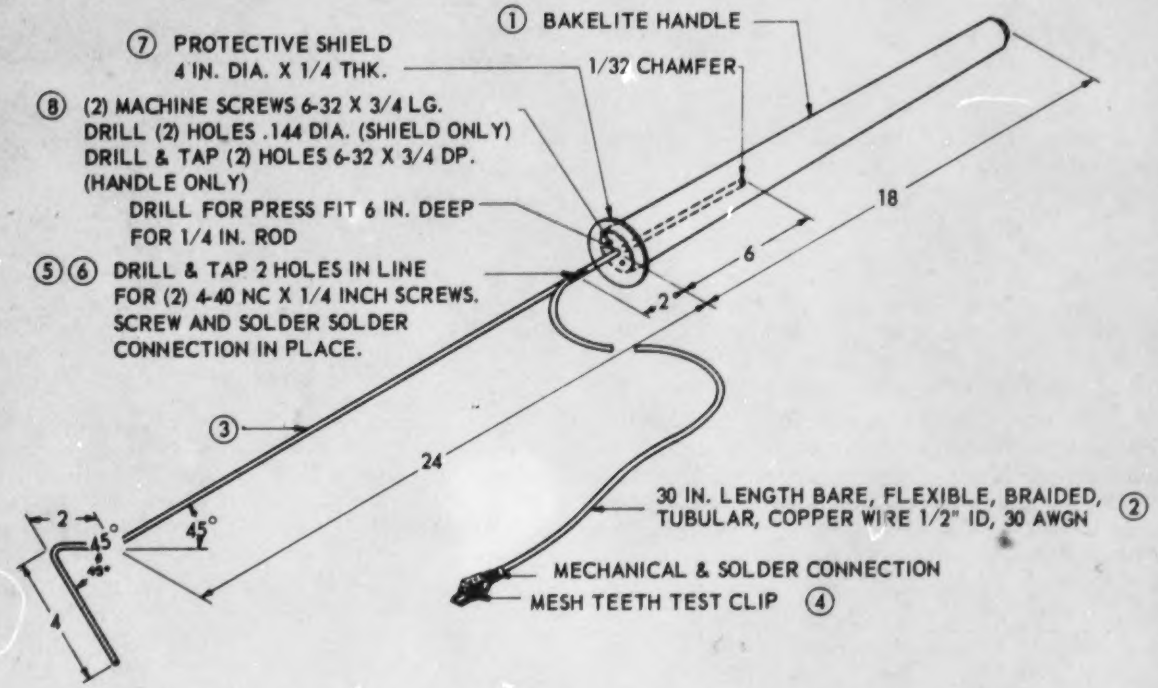
Electrical shock is a jarring, shaking sensation resulting from contact with electric circuits or from the effects of lightning. The victim usually experiences the sensation of a sudden blow, and if the voltage is sufficiently high, unconsciousness. Severe burns may appear on the skin at the place of contact; muscular spasm can occur, causing a person to grasp the apparatus or wire which caused the shock and be unable to turn loose. Electrical shock can kill its victim by stopping the heart or by stopping breathing or both. It may sometimes damage nerve tissue and result in a slow wasting away of muscles that may not become apparent until several weeks or months after the shock is received.

If a 60 Hz a.c. is passed through a person from hand to hand or from hand to foot, the effects when current is gradually increased from zero are as follows:

1. At about 1 milliampere (0.001 ampere), the shock will be felt.

2. At about 10 milliamperes (0.01 ampere), the shock is severe enough to paralyze muscles, and a person may be unable to release the conductor.

3. At about 100 milliamperes (0.1 ampere), the shock is usually fatal if it lasts for one second or more.


① BAKELITE HANDLE
⑦ PROTECTIVE SHIELD 4 IN. DIA. X 1/4 THK.
1/32 CHAMFER
⑧ (2) MACHINE SCREWS 6-32 X 3/4 LG. DRILL (2) HOLES .144 DIA. (SHIELD ONLY) DRILL & TAP (2) HOLES 6-32 X 3/4 DP. (HANDLE ONLY)
DRILL FOR PRESS FIT 6 IN. DEEP FOR 1/4 IN. ROD
⑤⑥ DRILL & TAP 2 HOLES IN LINE FOR (2) 4-40 NC X 1/4 INCH SCREWS. SCREW AND SOLDER SOLDER CONNECTION IN PLACE.
18
6
2
③
24
2
45°
45°
45°
4
30 IN. LENGTH BARE, FLEXIBLE, BRAIDED, TUBULAR, COPPER WIRE 1/2" ID, 30 AWGN ②
MECHANICAL & SOLDER CONNECTION
MESH TEETH TEST CLIP ④

1.1

Figure 7-22.—Approved type shorting probe.

It is important to remember that current, NOT VOLTAGE, is the killer and determines shock intensity. The amount of current that may flow through the body is determined by body resistance. That is, if the skin is dry and unbroken, body resistance will be quite high, on the order of 300,000 to 500,000 ohms. However, if the skin becomes moist or broken, body resistance may drop to as low as 300 ohms. Thus, a potential as low as 30 volts could cause a fatal current flow. Therefore, any circuit with a potential in excess of this value must be considered dangerous.

Rescue of Shock Victims

The rescue of shock victims is dependent upon prompt first aid. Unless you want to become a victim yourself, observe the following precautions:

1. Shut off the high voltage at once.

2. If the high voltage cannot be turned off without delay, free the victim from the live conductor, observing the following safety precautions:

   a. Protect yourself with dry insulating material.

   b. Use a dry board, belt, dry clothing, or other nonconducting material to free the victim.

   c. Use an axe, if necessary, to cut the high voltage cable or wire, taking care to protect your eyes from the flash when the wires are severed.

3. After removing the victim from the source, determine whether there is any breathing. Loosen the clothing about the neck, chest, and abdomen

so that breathing is facilitated. Protect the victim from exposure to cold.

4. Prevent movement by the victim; after shock, the heart is very weak and any sudden effort or activity may result in heart failure.

5. Send for a medical doctor or corpsman, and do not leave the victim until medical help has arrived. Do not give stimulants or opiates to the victim.

6. If the victim is not breathing, it will be necessary to apply artificial respiration without delay.

RF-Energy Burns

When passing through the body, a.c. above 10 kHz produces heat. Eventually, excessive heat results in the destruction of living tissue. From the standpoint of radio communications, the heating action penetrates through the tissue down to the bone, where skin nerves are not present to distinguish between sensations of "hot" and "cold". Thus, it is entirely possible for a person to sustain destruction of nerve tissue and body organs as a result of excessive heat, even though the individual feels little or no sensation. Furthermore, the consequences of such destruction may not be realized for some time. Delayed effects of both shock and RF heating include insanity, mental inertia, diseases of the blood vessels, eye cataracts, nerve disturbances of various kinds, disturbances in the heart conduction system, and destruction of the pancreas tissue. It is dangerous and foolish to deliberately subject oneself to a shock or an RF burn. In particular, the common practice of drawing an arc by means of a pencil is definitely unsafe.

Caution must be exercised when you are working on transmitting antennas, since a person's reaction to an RF burn may cause a fall from an elevated structure. Adequate precautions should be taken to ensure that transmitters are not energized when they are connected to an antenna that is being inspected or worked on. It should also be determined whether the RF energy from transmitting antennas in the area is harmful.

When working aloft, you should observe the following precautions:

1. Obtain permission from the CIC watch officer, communication watch officer (CWO), and OOD.

2. Ensure boiler safety valves are not being set by checking with the engineering officer.

3. Procure the assistance of a person qualified in rigging.

4. Wear a safety belt and secure it as soon as the work area is reached.

5. Secure tools to be carried aloft to your person with carrier lines.

6. Ensure good footing and grasp at all times.

7. Remember the expression: HOLD FAST.

Figure 7-23 shows standard hazard warning signs.

Cathode-Ray Tubes (CRTs)

Extreme caution should be exercised when you are handling a cathode-ray tube. The glass envelope encloses a high vacuum and will "implode" if punctured. To avoid serious injury, adequate precautions should be taken at all times to minimize the danger of breaking the glass envelope. Avoid scratching, striking, or using excessive force when handling the tube or when placing it in its socket. Never hold the tube by its narrow neck, and when setting the tube down, always stand it on its face on a thick piece of felt, if available.

Before a CRT is discarded, the tube should be rendered harmless by breaking the vacuum seal. This can be done as follows:

1. Place the tube, face down, in any empty CRT carton.

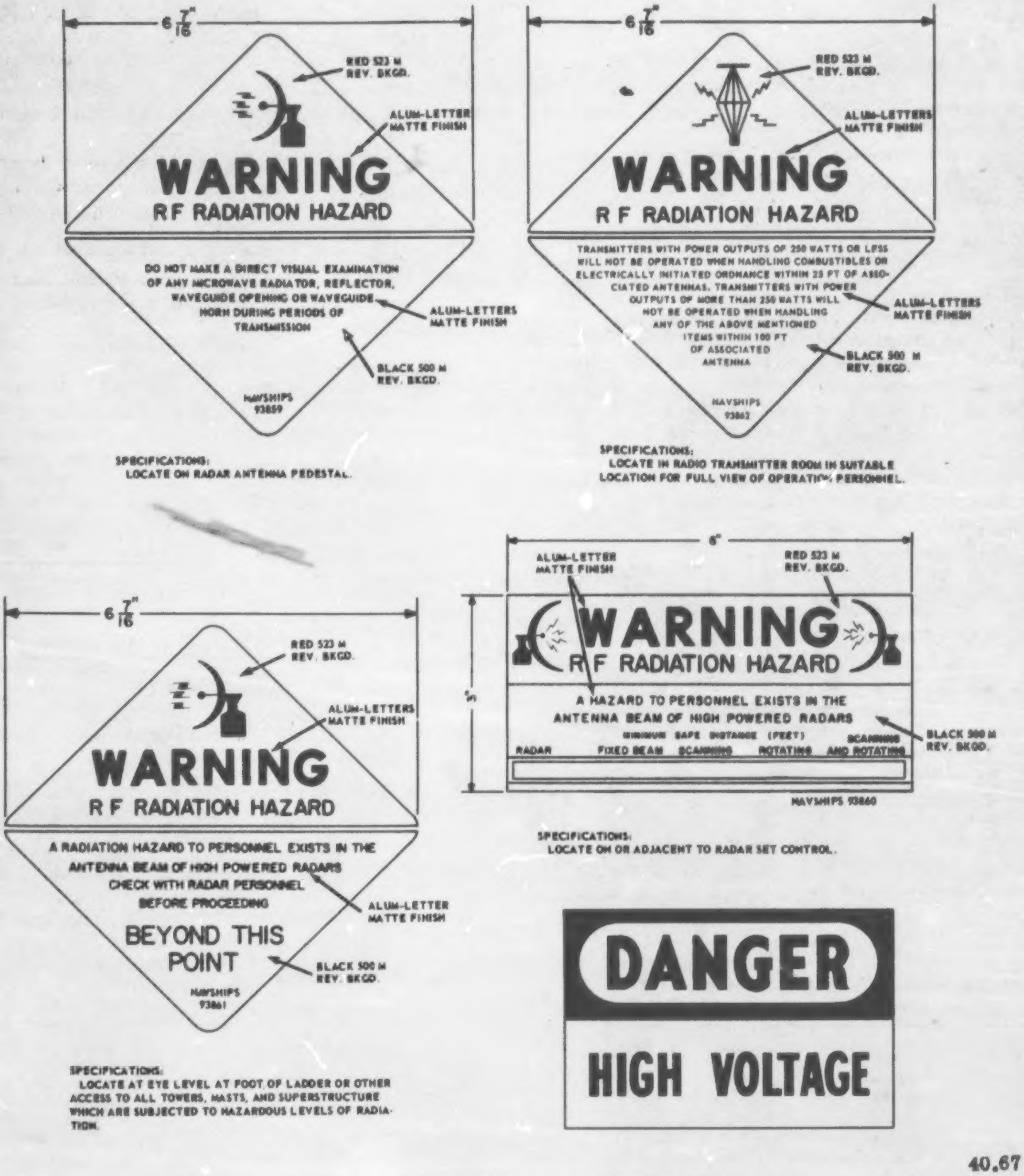
2. Carefully break off the locating pin from the base of the tube as shown in figure 7-24.

3. With a small screw driver or probe, break off the tip of the glass vacuum seal.

WARNING: The chemical phosphor with which the face of the CRT is coated may be extremely toxic. When disposing of a broken tube, be careful not to get any of this compound on your hands or into skin breaks.

Fire Precautions

In addition to observing such precautions as the proper storage of flammable liquids and the prevention of circuit overloading by using only properly rated fuses, you should make sure that fire extinguishers of the proper type are conveniently located near all high-voltage equipment. The following is a list of fire


6 7/16"
RED 523 M
REV. BKGD.
ALUM-LETTER
MATTE FINISH
WARNING
R F RADIATION HAZARD
DO NOT MAKE A DIRECT VISUAL EXAMINATION
OF ANY MICROWAVE RADIATOR, REFLECTOR,
WAVEGUIDE OPENING OR WAVEGUIDE
HORN DURING PERIODS OF
TRANSMISSION
ALUM-LETTERS
MATTE FINISH
BLACK 500 M
REV. BKGD.
NAVSHIPS
93859
6 7/16"
RED 523 M
REV. BKGD.
ALUM-LETTERS
MATTE FINISH
WARNING
R F RADIATION HAZARD
TRANSMITTERS WITH POWER OUTPUTS OF 250 WATTS OR LESS
WILL NOT BE OPERATED WHEN HANDLING COMBUSTIBLES OR
ELECTRICALLY INITIATED ORDNANCE WITHIN 25 FT OF ASSO-
CIATED ANTENNAS. TRANSMITTERS WITH POWER
OUTPUTS OF MORE THAN 250 WATTS WILL
NOT BE OPERATED WHEN HANDLING
ANY OF THE ABOVE MENTIONED
ITEMS WITHIN 100 FT
OF ASSOCIATED
ANTENNA
ALUM-LETTERS
MATTE FINISH
BLACK 500 M
REV. BKGD.
NAVSHIPS
93862
6 7/16"
RED 523 M
REV. BKGD.
ALUM-LETTERS
MATTE FINISH
WARNING
R F RADIATION HAZARD
A RADIATION HAZARD TO PERSONNEL EXISTS IN THE
ANTENNA BEAM OF HIGH POWERED RADARS
CHECK WITH RADAR PERSONNEL
BEFORE PROCEEDING
BEYOND THIS
POINT
ALUM-LETTER
MATTE FINISH
BLACK 500 M
REV. BKGD.
NAVSHIPS
93861
6"
5"
ALUM-LETTER
MATTE FINISH
RED 523 M
REV. BKGD.
WARNING
R F RADIATION HAZARD
A HAZARD TO PERSONNEL EXISTS IN THE
ANTENNA BEAM OF HIGH POWERED RADARS
MINIMUM SAFE DISTANCE (FEET)
RADAR
FIXED BEAM
SCANNING
ROTATING
SCANNING AND ROTATING
BLACK 500 M
REV. BKGD.
NAVSHIPS 93860
DANGER
HIGH VOLTAGE

SPECIFICATIONS:
LOCATE ON RADAR ANTENNA PEDESTAL.

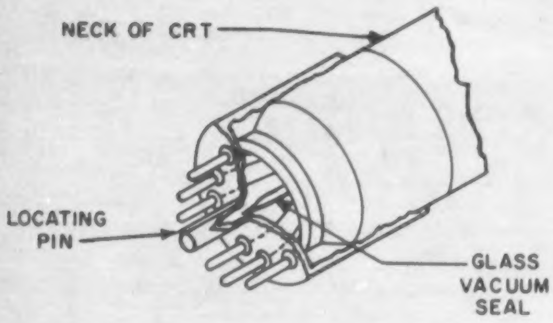
SPECIFICATIONS:
LOCATE IN RADIO TRANSMITTER ROOM IN SUITABLE LOCATION FOR FULL VIEW OF OPERATION PERSONNEL.

SPECIFICATIONS:
LOCATE AT EYE LEVEL AT FOOT OF LADDER OR OTHER ACCESS TO ALL TOWERS, MASTS, AND SUPERSTRUCTURE WHICH ARE SUBJECTED TO HAZARDOUS LEVELS OF RADIATION.

SPECIFICATIONS:
LOCATE ON OR ADJACENT TO RADAR SET CONTROL.

40.67

Figure 7-23.—Standard hazard-warning signs.



20.320
Figure 7-24.—Base of CRT and locating pin.

extinguishers that are normally available for your use:

1. Carbon Tetrachloride - Effective on electrical fires, as the compound is a non-conductor of electricity and will not damage electrical parts.

2. CO2 Gas - May be used on any fire, particularly on electrical fires.

3. Soda-acid - May be used only on ordinary fires, as the liquid is a conductor of electricity. Not effective on burning compounds, oil, etc.

4. Foam - Very effective on burning compounds, oil, and similar materials. Not satisfactory for electrical fires, as the compound is a conductor of electricity.

CHAPTER 8

SYSTEM DIAGNOSIS AND QUALITY ASSURANCE

To properly diagnose potential communication system trouble symptoms and to assure the most reliable equipment operating standards, efficient and accurate testing procedures are indispensable. Measurements are made periodically while the equipment is functioning properly to disclose any decline in the quality of equipment performance. However, even the most systematic checks available will not replace the operator's knowledge of basic communications systems and functional equipment operation. By combining your knowledge of basic systems and functional operation with proper communications testing procedures, potential problems are eliminated and equipments are operated at peak efficiency and reliability.

The term "system diagnosis and quality assurance" has tended to be confusing. "System diagnosis" simply means to detect a potential or real problem in a communications system and to isolate that problem through your knowledge of that system. "Quality assurance" is a planned, systematic pattern of actions necessary to provide relative confidence that a system or equipment will perform satisfactorily in actual operation. The PMS portion of the 3-M system provides part of quality assurance for us. System diagnosis and that overlapping part of quality assurance is provided through unscheduled, watch-to-watch, minor maintenance and the knowledge acquired by communications maintenance personnel. This chapter's objective is to increase your knowledge of the testing and assurance procedures of the more basic communication equipment.

TYPES OF OPERATOR MAINTENANCE

Generally speaking, there are two basic types of maintenance that radio operators must concern themselves with: OPERATIONAL and PREVENTIVE. Operational maintenance is considered a low-level of technical maintenance that an equipment operator may be able to perform while on watch or during in-port periods of equipment shutdown. This comprises such procedures as recording built-in meter readings, making front panel adjustments, or replacing minor parts, such as fuses, indicator lamps, etc. Operational maintenance also covers such routine inspections as visual inspections of equipments conducted for the purpose of finding and correcting conditions of dirt, corrosion, loose connections, mechanical defects, etc. Although these inspections overlap the category of preventive maintenance, operational maintenance can be considered separately, since this general maintenance is practiced routinely on a Navy-wide, and normally unscheduled, basis.

The most effective maintenance is preventive in nature since many potential failures are detected and corrected before they have a chance to develop. Normally referred to as "PMS", preventive maintenance is accomplished through the use of Maintenance Requirement Cards (MRCs) which outline the preventive task to be accomplished in a step-by-step manner. These scheduled maintenance tasks serve to reduce major equipment breakdowns and lengthen the useful life of the equipment or system. This form of maintenance consists principally of cleaning, lubrication, and periodic tests aimed at discovering conditions which, if not corrected, may lead to malfunctions. Often, preventive maintenance tasks require the use of basic test equipments.

TYPES OF SYSTEMS TESTS

There are numerous types of systems tests, at least as many as there are systems. Although it is possible to divide systems functionally by operation, systems may be simple, such as basic send-receive types, or complex, such as automated computers. Each, in turn, is made up of other separate systems. For example, voice transmission systems may be AM, FM, etc. Each system or subsystem is composed of certain groups of equipments or units. Testing may comprise all units or only one. For example, when making Quality Assurance (QA) checks on a transmitting system, you may be making radiation resistance checks on the antenna or output power measurements on the transmitter. You may make a simple insulation resistance check of the RF cabling between the transmitter and the antenna. These various tests and checks may be used in conjunction with your effort to diagnose a system problem and eliminate it or could possibly be made in accordance with regularly scheduled PMS checks. Therefore, it is easily seen that no one particular test or check can be considered as being a part of system diagnosis, or part of quality assurance only. However, it can be said that all of our tests, checks, and measurements combined serve to qualitatively determine the condition of systems, subsystems, and individual equipments.

System techniques vary from the extremely simple to the very complex, depending upon the type of system. More than one method may normally be used, depending upon the circumstances, what it is desirable to monitor, and the test equipment available. For example, a transmitter producing a modulated signal may be monitored by observation of the output meter on the transmitter front panel. A more refined method would be to connect an ammeter in series with the antenna lead. When antenna current remains steady, an unmodulated carrier is being produced. If the antenna current varies, the output is being keyed, or modulated. The observation of the output meter and the use of the ammeter essentially tell us the same thing. This is an example of having more than one method for performing a basic check.

You should always [illegible] the system technique that is most readily accessible, easy to perform, and provides the most information on operation of the system or subsystem. Normally, built-in monitoring setups are provided for most communications systems as operator's functions.

Basic systems tests may be subdivided into the following general categories:

(1) Overall performance tests.
(2) Minimum performance tests.
(3) Sensitivity/selectivity tests.
(4) Power input/output tests.
(5) Property measurements.

Overall performance tests/checks normally indicate the total capability of an individual piece of equipment or of an entire system. An example would be the testing of a transmitter in all operational modes (e.g., CW, AM, FM, SSB, FSK) in accordance with the performance standards normally contained in the equipment technical manual. This would indicate the overall capability of the transmitter.

Minimum performance tests are equipment checks or the minimum standards expected of a system. For example, if a transmitter is supposed to deliver 125 watts of power when an AM signal is fed into a properly tuned antenna but delivers only 95 watts, minimum standards are not met. Therefore, remedial action needs to be taken and the equipment brought up to minimum standards through proper repair or adjustments.

Sensitivity and selectivity checks are associated primarily with receivers. Sensitivity is the ability of a receiver to amplify a weak signal. Selectivity is the ability of a receiver to reject unwanted frequencies and accept only the one desired. However, the terms "sensitivity" and "selectivity" may be applied to any amplifier or frequency-determining network. Any piece of equipment that contains amplifiers or frequency-determining networks can be given sensitivity and selectivity checks.

Power input/output tests are self explanatory and normally deal with the ability of a transmitter or antenna to deliver or accept rated levels of power and operate at prescribed levels of efficiency. However, radiation resistance checks and field-strength tests are also considered part of power testing.

Property measurements are considered to be checks of basic electrical properties, such as resistance, capacitance, inductance, etc. An example would be a basic resistance test with an ohmmeter. This category is probably the most extensive of the basic tests and is discussed in the following paragraphs of this Rate Training Manual.

BASIC MEASUREMENTS

The following section will discuss the validity of basic resistance and voltage measurements as well as the usage of an oscilloscope in making various checks.

Resistance Measurements

Defective components and parts of equipments can usually be located by measuring the d.c. resistance between various points in a circuit and a reference point (or points), usually ground. This is due to the change in the resistance values of components whenever a fault develops. Point-to-point resistance charts in the equipment technical manual usually can be advantageously used for this. Always remember that, when taking resistance measurements, the values given in equipment charts are measured between the indicated points and ground. Also, remember to secure the power to the equipment under test and to discharge all capacitors before making resistance measurements.

Voltage Measurements

Since most troubles encountered in equipments and systems either result from abnormal voltages or produce abnormal voltages, you should consider voltage measurements indispensable aids in locating troubles when troubleshooting and in locating trouble symptoms when performing QA checks. Testing techniques that utilize voltage measurements also have the advantage that circuit operation is not interrupted. Point-to-point voltage measurement charts are normally contained in equipment and system technical manuals. These charts contain the normal operating voltages encountered in the various stages of the equipment. Unless otherwise stated, the values shown in the equipment charts are measured between the indicated points and ground.

When voltage measurements are taken, it is considered good practice to set the voltmeter on the highest range initially so that any excessive voltages existing in a circuit will not cause overloading of the meter. To obtain increased accuracy, the voltmeter may then be set to the designated range for the proper comparison with the representative value given in the voltage charts.

It should be remembered that the sensitivity (in ohms per volt) of the voltmeter used to prepare the voltage charts in the technical manual is always given on the chart; therefore, if a meter of similar sensitivity is available, it should be used so that the effects of loading will not have to be considered.

The following precautions are general safety measures, pertinent to the measurement of voltages, that you should follow when working with electronic equipment while making preventive or corrective checks:

(1) Connect the ground lead of the voltmeter first. While making measurements, place one hand in your pocket or behind your back.

(2) If the voltage to be measured is less than 300 volts, place the end of the test prod on the point to be tested.

If the voltage to be measured is greater than 300 volts, proceed as follows:

(1) Shut off the circuit power.
(2) Discharge the capacitors.
(3) Ground the point to be measured.
(4) Connect (clip on) the proper test lead to the high-potential point.
(5) Move away from the meter.
(6) Turn on the circuit power and read the voltmeter.

Do not come in contact with any part of the equipment while the power is on. You should constantly keep in mind that almost all voltages are dangerous and can be fatal if contacted.

Oscilloscope Measurements

Often referred to as "waveform comparisons", these measurements are considered to be a very important part of preventive maintenance, although they are used primarily in corrective maintenance. Waveforms may be observed at indicated test points, shown in waveform charts or on MRCs.

The waveforms given in charts, MRCs, or instruction booklets are often idealized and do not show some of the details which are normally present when the actual waveform is displayed on an oscilloscope. Consequently, many apparent "troubles" have been detected that really don't exist, resulting in many lost manhours of corrective maintenance in search of a problem that has been tentatively diagnosed. If there is no trouble present in the equipment or system, a waveform observed at a designated point generally should resemble the reference waveform given for that test point. However, test equipment characteristics or usage can cause distortion of the observed waveforms even though the equipment or system is operating normally. Some of the more common causes of these conditions are as follows:

(1) The leads of the test oscilloscope may not be placed in the same manner as those of the oscilloscope used in preparing the reference waveforms, or the lead lengths may differ considerably. These variations may cause the waveforms on the oscilloscope screen to appear distorted.

(2) A type of oscilloscope having a different input impedance and frequency response may have been used to obtain the reference waveforms.

(3) Operator front-panel errors may result from lack of knowledge of oscilloscope operation for test purposes.

In general, time should not be wasted in searching for faults when relatively minor differences are detected between the reference waveforms and those obtained by basic checks.

PERFORMANCE TESTING MEASUREMENTS

Performance testing of communication equipment and systems comprises specific tests for each category of equipment. In practice, performance checks determine the operating condition of a complete section of an equipment or system. Although they are normally covered in PMS, they also may be given as part of post-availability tests, post-overhaul testing, and special inspections. These tests are:

(1) Receiver noise measurements.
(2) Receiver gain measurements.
(3) Receiver sensitivity measurements.
(4) Transmitter power output measurements.
(5) Standing wave measurements.
(6) Frequency spectrum measurements.
(7) Impedance measurements of antennas and transmission lines.

Receiver Noise Measurements

In theory, it is possible to amplify a weak signal by any desired factor. For example, a receiver may have an amplification factor of 10 or 1000. This simply means that any signal introduced into the receiver input will be increased in amplitude 10 or 1000 times. The receiver amplification factor is closely linked to the receiver sensitivity. To distinguish between the two, it must be remembered that the sensitivity of a receiver is its ability to amplify weak signals; whereas, the amplification factor of a receiver is the relative increase in amplitude from the input to the output.

There is a limit to both the amplification factor and the sensitivity of a receiver. This limit is determined in all receivers by the amount of noise present in the receiver at any one time. The noise present in the receiver may come from random electrical disturbances in the atmosphere or from the electrical components in the receiver circuits. Whatever the source, the greatest amount of noise enters the receiver amplification circuits by way of the antenna input stage. If the noise originates in the atmosphere, it enters the receiver via the antenna proper. If the noise originates in the circuit components, it enters the receiver via the first RF amplifier. This is because only the noise generated in the first stage is amplified throughout the receiver. Noise generated in the rest of the receiver is not as harmful as that generated in the first stage of amplification.

Basically, what this means is that the crucial quantity in any receiver is the signal-to-noise ratio present at the input of the first RF amplifier. The absolute magnitudes of signal and interference are not important, only their ratio.

The noise generated through atmospheric disturbances can be controlled somewhat through the use of noise limiter, squelch, and volume control circuits whose operating controls are normally located on the front panel of the receiver. However, inherent receiver noise is a result of the design of the receiver itself and is harder to contend with. Therefore, it is safe to say that the inherent noise generated in a receiver establishes the minimum limit of signal that a receiver can usefully amplify, thereby determining the receiver sensitivity.

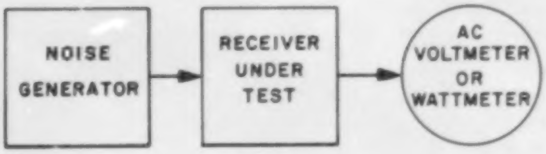
Self-generated receiver noise can be broken down into two distinct types: Thermal agitation and tube noise. Together, they can be considered collectively as receiver noise. Thermal noise is the result of the random motion of the electrons in the antenna and receiver circuits (also, sometimes referred to as "resistance noise"). Tube noise is the result of the noise existing between vacuum tube elements in the envelope and the guide pins at the base of the tube. This receiver noise exists across the entire RF spectrum and increases as the bandpass of a receiver increases.

At the higher operating frequencies, substantially all of the noise originates in the receiver. This is due to there being less atmospheric noise present at the higher frequencies; whereas, atmospheric and environmental noise generated externally from the receiver are greater at low-frequencies. In fact, noise in the microwave region of the spectrum is almost negligible external to the receiver.

Since receiver noise determines the weakest signal that can be amplified practically, its behavior and measurement are of fundamental inportance for equipment which may be used to receive very low-intensity signals. These receiver noise measurements are normally made with a noise generator or with an RF signal generator.

Basically, a noise generator is designed to produce a random noise signal at any number of frequencies within its design frequency range. For example, a noise generator with a frequency range of from 2-32 MHz can produce a signal consisting of pure noise at any frequency between 2 MHz and 32 MHz. The noise generator method of determining the noise figure of a receiver has the advantage that no knowledge of the gain of the receiver or amplifier under test is necessary. This method of measurement consists of comparing the noise actually present in the receiver or amplifier with the nonvarying, calibrated output of the noise generator. It should be remembered that a noise measurement can be made on an individual amplifier or on an entire receiver.

Figure 8-1 shows a block diagram for making a noise test on a receiver using a calibrated noise generator. For an accurate measurement, the noise generator output impedance is adjusted to be the same impedance as the normal signal source to the receiver or amplifier circuit under test. In most cases, this input impedance value is given in the equipment technical manual and is the impedance at the antenna input, since the signal is normally injected at the first RF amplifier of a receiver under test. For best results, the shortest possible leads should be used between the noise generator and the receiver input. Also, leads with good connectors should be used. Ideally, the measurements are performed in a shielded room. If this is not possible, a location should be chosen where a minimum of interference from radio transmitters or other electrical devices will be encountered.



76.117

Figure 8-1.—Block diagram of a basic receiver noise measurement.

As is shown in figure 8-1, the noise generator output is injected into the receiver at the desired frequency in accordance with the standards and specifications set forth in the equipment technical manual or maintenance standards manual. The meter used at the output is normally an a.c. voltmeter. The automatic volume control and noise limiter circuits should be disabled when this test is performed.

When a voltmeter is used as the output indicator, the receiver is first observed with no input signal applied. Then, the noise generator is adjusted for an output voltage of 1.4 times the no-input voltage indication. The noise figure is then indicated on the output level control of the noise generator. If a wattmeter is used as the output indicator, the noise generator should be adjusted for twice the no-input reading.

The signal generator method of making receiver noise measurements is similar to the noise generator method in that the basic block diagram is the same as that shown in figure 8-1. The only difference is that a signal generator is used instead of a noise generator. This method has an advantage in that sine wave generators are more prevalent and easier to come by than noise generators. However, the signal generator method is not as practical or accurate as the noise generator method. When using the signal generator, you must take into account the bandwidth and the response of the receiver under test, something you don't have to do with the noise generator method. Using the signal generator, the procedure is the same in that the measurements are made under conditions of no-signal and signal inputs.

Receiver Gain Measurements

Gain measurements are useful in determining the gain of a particular amplifier within a receiver or of an entire receiver from input to output. The gain of a particular stage within a receiver is expressed by the fundamental equation:

$$\text{Voltage Gain (VG)} = \frac{\text{Voltage at Succeeding Stage}}{\text{Voltage at Input Stage}}$$

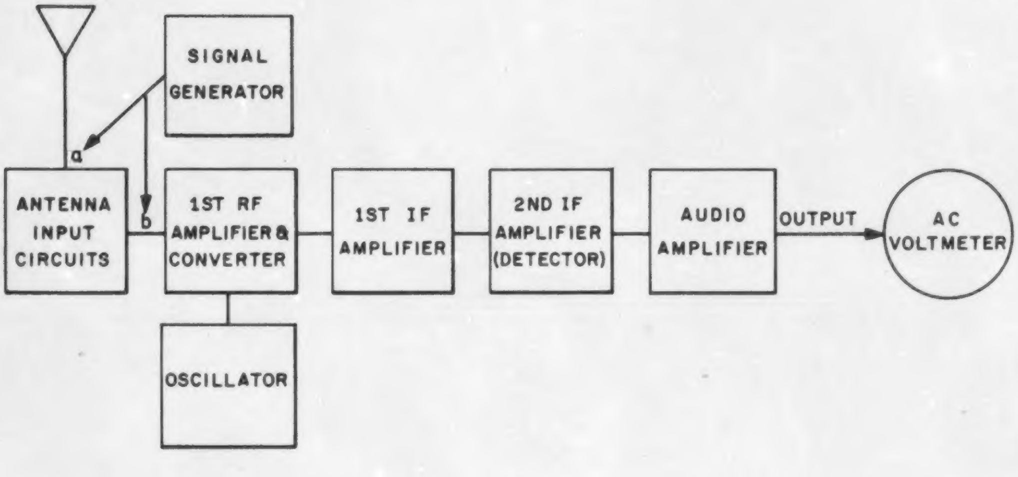
That is to say, by inserting a test signal at the input stage and measuring it at the input to the succeeding stage, we can determine the voltage gain (VG) of the input stage. Similarly, the voltage gain (or gain) of an entire receiver is determined. By inserting a signal into the antenna or the first RF amplifier stage and measuring it at the output of the receiver, with a voltmeter we can determine the gain of the entire receiver. Expressed as a formula:

$$\text{Receiver Gain (RG)} = \frac{\text{Output Signal}}{\text{Input Signal}}$$

It is important when gain measurements are made that the normal operation of the stage not be disturbed by the test equipment involved. Figure 8-2 shows a basic block diagram of a typical AM receiver. A signal frequency from the signal generator may be inserted at either point "a" or point "b". The signal that is injected and the connections that are made must be in accordance with technical manual specifications or the maintenance standards manual. The output of the receiver is measured with a voltmeter connected at the output of the last amplifier stage. Interpretation of the voltage reading from the input to the output will give us the total gain of the receiver. This method may also be used between single stages, measured one at a time.

Receiver Sensitivity Measurements

Sensitivity measurements provide a convenient overall measurement of a receiver. In addition to being the ability of a receiver to amplify weak signals, sensitivity also can be defined as the input carrier voltage required to develop a standard value of output. Sensitivity measurements require the application of an accurately calibrated signal to the antenna input terminals of a receiver, normally through a "dummy" antenna which approximates the impedance characteristics of the antenna with which the receiver is designed to be used. This dummy antenna simulates normal operating conditions and ensures that the receiver has the proper impedance match and that the signal current during testing is equivalent to the signal current



76.118

Figure 8-2.—Basic block diagram of receiver gain measurement using signal generator.

obtained from a real signal of equivalent magnitude. Figure 8-3 shows in block form a typical signal generator, dummy antenna, and receiver hook-up in preparation for sensitivity measurements.

Most signal generators have an output impedance of approximately 50 ohms. Most low impedance receivers have an input impedance of approximately 50 ohms as well. Therefore, for sensitivity measurements of these low impedance receivers with a corresponding signal generator, no dummy antenna is necessary. The dummy antenna is necessary only where the impedances between the signal generator and receiver must be matched for proper measurements.

As shown in figure 8-3, the signal generator injects a signal into the dummy antenna. This injected signal must be in accordance with either the technical manual or reference standards tables. The signal is then inserted into the receiver input circuits as it normally would be. At the output of the receiver, an indicating device, such as a voltmeter, is used to measure the value of the test output in reference to the standard test input of the signal generator and, thereby, determine the sensitivity of the receiver. To obtain valid results, it is important that the step-by-step procedures and connections are made in accordance with the equipment technical or reference standards manuals.

Power Output Measurements

The measurement of power output is important in determining the efficiency and proper operation of all output stages and systems. It is applicable to audio frequencies as well as radio frequencies. For continuous wave (CW) transmissions, the power output is measured under key down conditions for maximum output into a properly terminated antenna system or a dummy antenna of equivalent characteristics.

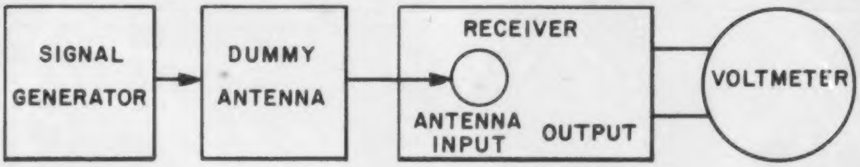
In modulated systems, the power output is measured for normal carrier output and for peak power at 100 percent modulation. An oscilloscope is normally used to determine the drive necessary for 100 percent modulation. Exceeding this drive level will cause distortion and unwanted shifting of the carrier.

Needless to say, there is an output power measurement for every type of transmitter in operation. These measurements are simpler to make than, say, sensitivity measurements. However, unless proper technical manual precautions are followed to the letter when the measurements are made, the test equipments used in conjunction with these tests will be permanently damaged and made inoperative.

In conjunction with power measurements are standing-wave ratio (SWR) measurements. Standing-wave ratio tests and measurements are included in the scheduled preventive maintenance procedures for equipments which are applicable to this type of test. It is basically a test of the ratio of current or voltage at a loop to current or voltage at a node along the length of the antenna. A low standing-wave ratio is indicative of a properly matched system and is a prerequisite for good performance of all communications transmission lines which are intended to match the load and source impedances. Procedures for checking the current or voltage variations which are the components of the standing waves are dependent fundamentally upon the frequency of the system. Again, technical manual and reference standards procedures should be followed when these checks and measurements are made.

Frequency Spectrum Measurements

The amplitude of a group of frequencies that comprise a signal is termed the "frequency



76.119

Figure 8-3.—Typical block diagram in preparation for sensitivity measurement.

spectrum" of the signal. Various types of equipment provide a visual or a meter indication of the spectrum. Those equipments which are used for observing or measuring segments of the audio frequency band are called wave analyzers, distortion analyzers, and sound analyzers. Those employed for observing large segments of the RF spectrum are called panoramic adapters or signal analyzers. Test equipments used for observation of small segments of the RF spectrum, or of RF oscillators, are called spectrum analyzers or pulse analyzers. The equipment most used in communications checks is the spectrum analyzer. Some of the more important checks that can be accomplished with the spectrum analyzer are:

(1) Operation of transmitter local oscillators.

(2) Operation of automatic frequency controls.

(3) Frequency and side-band measurements.

(4) Power measurements.

Impedance Testing of Antennas and Transmission Lines

The amount of current that flows in an antenna is one of the most important factors affecting the reliability of communications. Thus, in order to secure the maximum radiated power from a transmitter, as much of the generated RF energy as possible must be efficiently transferred to the antenna. Also, for optimum reception, the maximum transfer of energy from the antenna to the receiver must occur. Efficient transmission and reception conditions prevail whenever the transmitter or receiver is properly matched to the transmission line and the transmission line to the antenna.

Normally, antennas and transmission lines are installed as an integral part of the equipment with which they are used, and performance tests concerning impedance matching consist primarily of taking SWR measurements. However, in certain instances, it will be found that an undesirably high SWR will be obtained, caused by a change in antenna impedance. This could be the result of a new antenna installation or the erection of a structure in the proximity of the antenna so that the structure influences the antenna characteristics. In practice, the antenna matching network is generally varied to match the new antenna characteristics since the transmission line is designed to match the equipment impedance. This can be done by making a series of SWR checks and antenna matching adjustments until an acceptable SWR is reached.

Often, when high SWRs are obtained for no accountable reason, a check of the transmission line or antenna impedance is in order. This would be particularly true when there have been no additions to the existing installation and no new structures have been erected in proximity to it. The most standard check of transmission lines, control cables, and antennas is the impedance check. This is normally done with a megohmmeter. In so doing, the insulation resistance of the cabling can be checked and the "breakdown potential" determined. The input impedance of the antenna also can be checked to determine if the "characteristic impedance" is in accordance with technical manual standards. Characteristic antenna impedance normally can be checked with an ohmmeter.

Electron Tube Testing

Electron tube failures are responsible for the largest percentage of troubles that occur in electronic equipments or systems. However, if a particular equipment or system uses a great number of tubes, it is obviously impractical to attempt to diagnose potential problems by general tube checking. Often, when a preventive maintenance (PM) check reveals a potential problem, the work center supervisor or operator will resort to massive tube replacement in an attempt to diagnose the PM failure. All that is usually accomplished is that the equipment in question is severely misaligned upon completion of tube substitution and the PM still reveals a potential problem. Only when a problem has been diagnosed to a particular stage should any electron tubes be tested, and then only those associated with the improperly functioning circuit.

When replacing a tube in a circuit, note and record the positions of the front panel operating controls before changing the setting of any of them. Test the new tube for shorts before inserting the new tube into the circuit. If adjusting the front panel controls with the new tube in place does not correct the abnormality, return the controls to their original positions, and, unless a reliable tube tester shows the original tube to be defective, reinsert the old tube in the original circuit. Do not change tubes indiscriminately; otherwise tubes whose exact age and condition are unknown (or uncertain) will accumulate. In many high frequency equipments when tubes are changed, the tuning of the circuits may be upset. Thus, when tube substitutions are made, the unit may often have to be realigned.

RECEIVER QUALITY ASSURANCE

Communications receivers are composed of a series of selective RF and AF circuits, each stage of which is designed to amplify the output of the preceding stage. The lowered efficiency of any one tube, or a change in any one circuit parameter, usually results in lowered overall efficiency of the receiver. The sensitivity of the receiver may also be decreased by the misalignment of the successive circuits, each of which may function in a suitable manner as a unit. The sole function of a communications receiver is to selectively receive a weak signal; therefore, an objective overall test of the receiver sensitivity is the most significant single check that can be made on the condition of a receiver.

Some receivers are provided with a built-in output meter; others have an output meter equipped with a cord and plug to facilitate testing. The only other requirement for a sensitivity check is a standard signal check of receivers on the various bands. During radio silence, this signal may be provided by a calibrated signal generator with a dummy antenna coupled directly to the receiver input. When it is permissible to operate transmitters, the output of the signal generator may be fed into a central radiating antenna, and receivers may be calibrated from the signal received by their own antennas. Any decrease in sensitivity should be corrected.

It should be noted that sensitivity and selectivity may be affected by the alignment in all types of receivers. As receivers become more complex, alignment becomes more of a problem. In AM receivers using conventional sideband signals, improper alignment may result in the loss of weak signals through loss of sensitivity and the inability to select the desired signal. When a receiver has AVC and AFC features, proper alignment may be complicated if procedures are not followed exactly.

In addition to periodic checks on sensitivity, routine physical inspections must be made of the receiver and accessory units. Lubrication and cleaning schedules recommended by the technical manual, Maintenance Standards Book, and PMS must be followed. Tubes should be tested sparingly because frequent insertion and removal weakens the socket contacts and causes noisy or intermittent operation. Electron tube life generally extends to several thousand hours; therefore, in equipment which is continously operated and on which periodic sensitivity tests are made, tubes should be checked only when performance indicates such a need. When tubes are replaced in RF circuits, the circuits should be realigned, if necessary, to achieve normal sensitivity. Before new tubes are used, it is good practice to check them on a tube tester.

Methods of adjusting and servicing each type of equipment are discussed in detail in the technical manual or manuals furnished with each equipment as well as in normal PMS checks. Whenever a problem is detected, you should proceed methodically in locating the fault by testing first the most accessible and vulnerable parts of the receiver. If the problem goes beyond operating personnel's knowledge or experience, it should be referred to appropriate repair personnel. Anytime a receiver is temporarily removed from its assembly for testing, it should be thoroughly cleaned and inspected so that parts close to failure may be detected beforehand. Since receivers could operate for many years with reduced sensitivity before a complete failure occurs, the preventive maintenance schedule for each receiver should be followed. In this section, we will discuss many of the areas associated with receiver quality assurance.

Assurance, Diagnosis, and the Decibel (dB)

Until now, a very important term with reference to quality assurance and systems diagnosis has been omitted. That term is "decibel", abbreviated "dB". It is an important term in that it is used in conjunction with many areas of quality assurance and systems diagnosis that are of interest to the communications operator and supervisor. For example, during QA checks in accordance with MRCs or technical manuals, you will often find the gain of a particular amplifier stage expressed in dB. Many trouble charts and reference levels listed in technical manuals and Maintenance Standards Books are given in dB. Therefore, it is important that you, as an operator and supervisor, understand the definition of the term "decibel" and can equate it to the basic systems checks that you must often make.

The international unit, the "BEL", is a unit of gain equivalent to 10 to 1 ratio of power gain. Thus, the gain in bels is simply the number of times that 10 is taken as a factor to equal the ratio of the output power of an amplifier to the input power. If, for example, the output power of an amplifier is 100 times the input, the ratio is 100 to 1, or 10^2 to 1. The gain is therefore 2 bels, the number "2" being the number of times that 10 is taken as a base factor, as shown in the number "10^2". One bel is equal to 10 decibels, and vice-versa. Therefore, the gain in decibels is 10 times 2, or 20 decibels.

Where the amplification factor of an amplifier is listed as a 1000 to 1 ratio amplifier, it may be written as 10^3 to 1, or 3 bels, and the gain in dB is 10 x 3, or 30 decibels.

Where the gain of a stage in a piece of communications equipment is listed as being increased 10,000 times, that gain is 10^4 to 1, or 4 bels. Therefore, the gain in dB is 10 x 4, or 40 decibels.

As you can see, the easiest way to determine the gain in decibels is to multiply the base number of 10 by the number of times that it must be multiplied by itself to equal the amplification factor; 10^6 equals 10 x 10 x 10 x 10 x 10 x 10. It also equals 6 bels and 60 decibels. Table 8-1 shows the general relationship between dB and gain ratio.

TABLE 8-1

dB and Gain Ratio

Gain Ratio	Factor	No. of BELS	No. of dB
1,000,000 to 1	10^6	6	60
100,000 to 1	10^5	5	50
10,000 to 1	10^4	4	40
1,000 to 1	10^3	3	30
100 to 1	10^2	2	20
10 to 1	10^1	1	10

It should be remembered that decibels can be expressed either positively or negatively. In other words, an amplifier that amplifies the input 100 times has an amplification factor of 100 to 1, or 10^2, or +20dB. Conversely, if an attenuator reduces the level of a signal by the same amount, it is said to have a loss of -20dB. Needless to say, anyone who participates in almost any area of quality assurance and systems diagnosis requiring the use of equipment and systems technical manuals must have a basic knowledge of the usage of decibels. This is particularly true when receiver QA checks are undertaken, especially those dealing with sensitivity, selectivity, and bandwidth measurements.

Single Sideband Sensitivity Measurements

Sensitivity measurements of SSB receivers are determined in a manner similar to that used for other amplitude modulation equipment. However, certain considerations must be taken into account when measurements are performed on this type of equipment. For example, the frequency stability requirements of SSB equipment operating in the high frequency range are on the order of 0.2 to 2 parts per million. Frequency errors greater than 30 Hz can cause voice transmissions to be unintelligible with certain signal-to-noise ratios. Intelligibility decreases with an increase in frequency error, even with a high signal-to-noise ratio. When frequency conditions are simulated for the sensitivity measurements, this same high degree of accuracy is still warranted. Therefore, proper measurements for single-sideband receivers should include the use of test equipment designed for use with this type of communication equipment or test equipment with an accuracy equal to, or better than, the accuracy to be maintained in the receiver.

CW and Facsimile Sensitivity Checks

Sensitivity checks and measurements for CW (A-1) and facsimile (A-4) are essentially the same. In basic front panel setups for determining their reception sensitivity, you should set the BFO to ON and the receiver audio gain at maximum. If the tone control positions are not specified in the receiver technical manual, tone controls should be set for maximum audio range. The signal generator is to be used unmodulated. Following initial adjustments stated in the technical manual or on the MRC, the carrier is then applied from the signal generator, and the input signal voltage is adjusted to produce a +20dB output, signal-to-noise ratio (100 to 1). The receiver sensitivity, in terms of input signal voltage, is then read from the signal generator voltage calibration. Many reference levels may be used, but the 20dB relationship should be maintained.

Voice Modulated Sensitivity Checks

In determining voice-modulated (A-3) sensitivity, a carrier of 400 Hz must be applied at 30 percent modulation. The RF gain control should be set at maximum with AGC ON and the BFO OFF. All other controls should be set as indicated for CW reception with the exception of the AF gain control. After consulting the applicable technical manual or MRC card and the modulated output of the signal generator applied, the receiver output should be adjusted for a +10dB ratio of signal-to-noise (10 to 1). The receiver sensitivity is then read from the signal generator voltage calibration.

FSK Sensitivity Determination

In an FSK system, the receiver, frequency-shift keying circuitry, and the teletypewriter must all operate satisfactorily to produce proper copy in FSK operation. If the receiver checks satisfactorily for CW operation and sensitivity, only the additional switching for FSK reception and any special FSK filters located inside the receiver could produce poor FSK operation so far as the receiver proper is concerned. Therefore, the receiver may be checked for FSK sensitivity by initially checking its standard CW sensitivity. If this proves to be normal, switching to FSK operation will allow the [illegible] and audio levels to be checked to ensure [illegible] they meet the requirements of whatever type of audio frequency FSK converter is employed.

The output which the receiver produces for an IF converter in FSK operation may be checked with an electronic voltmeter capable of good accuracy at the IF and with a range of 0.001 volt to at least 10 volts. The receiver and converter technical manuals should be consulted for standards of receiver output in this case.

Reserve Gain Determination

"Reserve" gain for all types of reception may be determined by measuring the ratio of noise output at standard gain (the gain condition used in measuring standard sensitivity) to noise output at maximum gain, provided that maximum gain does not cause an output overload.

It should be noted that there is also a gain variation with a change in frequency bands. The response to the input signal will not be the same from band to band nor will it be the same from point-to-point in the same band. This variation over each band may be determined by adjusting for standard gain (as for sensitivity measurements) at the high frequency end of each band and then noting the input signal voltage required at various frequencies over the band to produce the same input.

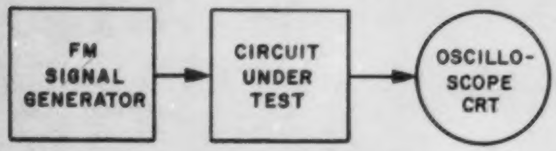
Receiver Response Curves

Every receiver has a series of amplifiers and detector circuits that both reduce the signal to an audio or IF level and amplify that signal as necessary. Each receiver amplifier circuit is made up of separate electronic parts and, though similar, have operating characteristics all their own. One of the characteristics of separate amplifier circuits is that no two amplifiers will amplify or respond to the same signal in exactly the same way.

It is possible to determine the exact way that each amplifier inside a receiver will react to a series of frequencies within the range of the receiver. It is also possible to obtain a visual display of the reaction of separate amplifiers to the same frequency bands, thus determining their "response curves".

A visual response curve may be produced by applying an output signal from an FM signal generator to the receiver circuit being checked and employing an oscilloscope as an output indicator, (see figure 8-4). The FM signal from the generator will usually vary at a 60 Hz rate about a center frequency.

The original FM signal is changed in passing through the amplifier so that the output signal from the amplifier consists of an FM signal which is amplitude modulated. The resulting "envelope" appearing at the output will appear on the oscilloscope screen, but only after being "detected", because the output of the amplifier is varying at an RF rate and cannot be seen. However, after detection, only the modulation remains, and this appears on the oscilloscope in



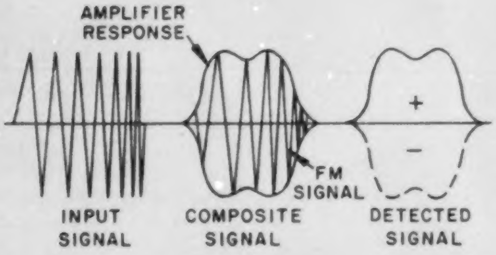
76.120

Figure 8-4.—Equipment arrangement for determining response curve.

the form of the response curve of the amplifier. (See figure 8-5). The detector polarity determines whether a positive or negative output occurs on the visual presentation; the output response curve will appear inverted if the output is of negative polarity. However, the response curve may be used in whichever position it appears at the output of the detector. Since, for equal deviations, the positive and negative portions of the envelope are symmetrical, it is necessary to observe only one side of the envelope.

Receiver Selectivity and Bandwidth Measurements

Selectivity is the property which enables a receiver to discriminate against transmissions other than the one to which it is tuned. The term "overall selectivity" usually refers to the frequency selectivity of a receiver as measured from (and including) the antenna to the input of the final detector. It does not normally include any elements of the audio signal because most of the selection and rejection of input signals have already been accomplished by the time the audio stages have been reached.



76.121

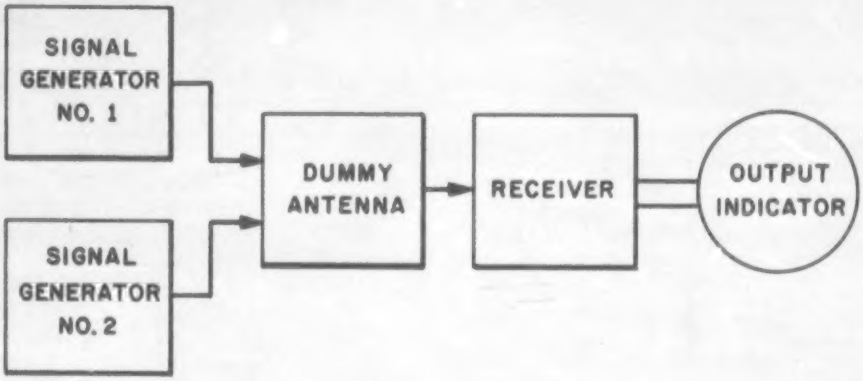
Figure 8-5.—Typical amplifier response curve.

The bandwidth of a receiver defines the frequency range over which the amplification is relatively constant. For most receivers, the bandwidth represents the usable portion of the modulated intelligence. Selectivity and bandwidth measurements can be made with similar test equipment and connections, such as those shown in figure 8-3. Automatic volume control is normally turned OFF and the volume control is set to maximum for these measurements. The signal generator is set at the receiver frequency and modulated in accordance with test instructions. The RF gain control should be adjusted for a convenient reference level on the voltmeter, or as specified. The signal generator output is then varied in accordance with test instructions. It is emphasized that test procedures may vary according to whether the receiver is considered a "narrow-band" or a "wide-band" receiver, and technical manual step-by-step procedures should be very carefully followed.

Cross-Modulation Test

A cross-modulation test is, in a sense, a selectivity test. However, it has the advantage of determining the effect of "interfering" signals with the automatic volume and gain controls in operation, which is the situation that will normally be encountered during receiver operation. This test requires the use of two signal generators. One signal generator is set at the frequency to which the receiver is tuned, while the other is tuned away from the test frequency in order to represent the interfering signal. (See figure 8-6.) This technique has the advantage of simulating the condition that exists when the receiver is tuned to a station close to another strong signal that interferes with primary communications. It is a valid test because practically all receivers must be able to properly function with interference in the crowded frequency spectrum.

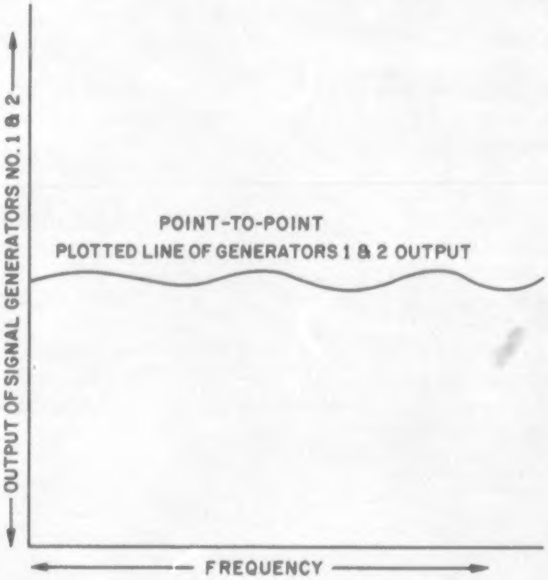
The cross-modulation test gives no information concerning the attenuation of a desired signal in the presence of a strong interfering signal. This type of apparent signal loss occurs when the combined strength of the desired signal and the interference is sufficient to cause overloading of the receiver, or, in the case of a poorly designed automatic-volume control (AVC) network, to cause a reduction of the output. Therefore, in conjunction with the cross-modulation test, we have what is referred to as



76.122

Figure 8-6.—Typical equipment arrangement for a cross-modulation test.

a "blocking interference" test. A blocking interference test uses the same basic equipment configuration shown in figure 8-6. Basically, this test is plotted on an output versus frequency graph using the outputs of signal generators 1 and 2 from the cross-modulation test. Generally speaking, the straighter the line on the graphic plot, the less the attenuation, (See figure 8-7 for a typical blocking-interference graph).



76.123

Figure 8-7.—Typical graphical plot of results of a blocking interference test.

Squelch (Silencer) Circuit Measurements

High frequency receiver circuits inherently have a high noise level when no signal is being received. During communications, where a receiver is tuned to a specific frequency for long stand-by periods in anticipation of signals that may appear at any time, the continuous roar of noise is highly annoying to anyone in the vicinity of the receiver. Therefore, it is desirable that a squelch (or silencer) circuit be incorporated to silence the audio output during these periods when no signal is being received. The squelch circuit works in conjunction with the audio amplifier to block the received interference in the form of noise or low-level signals from interfering stations.

The received signal level necessary to operate the squelch circuit in a receiver is called the receiver's "squelch characteristic". In an AM receiver this characteristic may be determined by first making the equipment connections shown in figure 8-3. The signal generator should be set to 30 percent modulation at a frequency of 400 Hz. With the signal generator RF output set for zero, the receiver output should be noted; it should be essentially zero. Gradually, the signal generator RF output should be increased until the squelch circuit operates. Operation of the squelch circuit is indicated by a sudden increase in the radio receiver output. The RF output of the signal generator required for the operation of the squelch circuit may be recorded as the squelch characteristic of that receiver.

Tuning Dial Calibration

Tuning dial frequency calibration can be checked against any known standard, such as WWV or WWVH. Some receivers have built-in crystal calibrators which give signals spaced throughout the range of the receiver. A heterodyne frequency meter may also be used, the output of which may be fed to the receiver antenna terminals. With any of these means, the tuning dial error should be carefully observed. If the error is excessive (more than ±1 percent) and shows a definite progression with frequency, the receiver may require realignment.

Warm-up Frequency Drift

Frequency changes which occur while the receiver is warming up may be measured by setting a heterodyne frequency meter to give a 1000 Hz beat note output from the receiver in the CW mode of operation. This is done as soon as the receiver is turned on. Then, as the receiver drifts, the frequency meter is readjusted to produce this same beat note. When the output frequency becomes essentially stable, the total frequency drift is indicated by the difference between the final and original frequency settings of the frequency meter dial.

COMMUNICATIONS TRANSMITTER TESTING

Because of the necessity to match the output of transmitters to their respective antennas, the operation of a transmitter is usually more complex than that of a receiver. Like receivers, there are many tests and measurements to be made in order to ensure the proper operating condition of transmitters. Most of these checks are on a maintenance level and are performed by qualified repairmen. However, there are some tests and checks that operating personnel can make in order to ensure continuity of communications. Most of these tests and checks are covered by the PMS requirements and are fairly standard.

Because of the power involved when a transmitter is operated, the most vulnerable part of its operating circuits are the vacuum tubes. The operating procedures for most radio transmitters call for continuous tuning and retuning, and PA stage tube currents are usually measured by means of front panel meters. By periodically recording these output readings, the cumulative record bears the same relationship to the transmitter that a sensitivity check does to the receiver. Whenever the emission of a tube falls to 80 percent of normal rating, it should be replaced. Large PA tubes also have a tendency to fail when stored for long periods of time. Therefore, they should be rotated with tubes of the same type in spare storage so as to maintain three sets of large tubes in good condition at all times.

Ventilation and dust conditions present a greater problem to transmitters than they do to receivers, primarily because there is more heat to be dissipated. Dust forms a film which absorbs moisture and lowers the insulation resistance of circuit components. In so doing, a "flash-over" or "arc-over" point of potential can develop between two components closely located to each other. This arc-over is in the form of a charge of electrical energy flashing from a negatively charged point of electrical potential to the less negative point (the point now covered with moist dust). Therefore, cleaning periods must be initiated and regularly followed. These periods will vary for different locations. Insulators must be wiped, corroded metal parts cleaned, and arc-overs repaired. It is possible to detect poor contacts by inspecting for evidence of overheating. When overheating is found, these contacts must be thoroughly cleaned. It is also important that transmitter antenna connections be regularly inspected and cleaned.

During periods of radio silence, the proper tuning of transmitters presents a problem because an appreciable amount of RF energy must be prevented from radiating. By previous tuning of the transmitter through a great number of operating frequencies with accurate logging of all the dial readings, the need for operation during radio silence is eliminated. Many technical manuals also have a listing of approximate front panel settings that correspond to transmitter frequencies. Normally, through intelligent interpolation, between-frequency settings can be closely arrived at.

Frequency Measurements

Transmitter frequency measurements are necessary for reliable operation and compliance with communications regulations. These regulations concern self-generated multiples of the selected frequency (called harmonics), sidebands, and tolerances allowed for the assigned frequency of transmission.

A method of frequency measurement commonly used in transmitting spaces is the application of installed frequency standards. Normally, these installed standards are a combination of a series of very stable oscillators that may be hooked up to the transmitter as convenient frequency references. Often, one frequency standard may service all receivers and transmitters located in a communication space. This piece of equipment may also be referred to as a standard frequency generator. A good example of a standard frequency generator, normally installed as a reference frequency standard, is the AN/URQ-9 shown in figure 8-8. The reference frequencies are provided through the output jacks located on the front panel of the standard (lower-left of figure 8-8). Patch cords can be connected between these jacks and the input jack desired on the transmitter front panel. From there, the frequency selected from the AN/URQ-9 can be used as a reference in conjunction with whatever transmitter oscillator it was intended for.

Another method of frequency measurement is the "heterodyne frequency meter method". The method employed is similar to that used to "zero-beat" a receiver for calibration. Basically, the frequency to be measured is "beat" against the output signal of the frequency meter internal oscillator. Many heterodyne meters also include an antenna for receiving a radiated signal. Assuming that the instrument is placed near enough to the source of the signal whose frequency is to be measured, this provision eliminates the need for a direct connection between the frequency meter and the source to be measured. Using this method, set-up and operation instructions must be explicitly followed and the calibration consulted for proper interpretation of the frequency meter results.

Output Power Measurements

Many feel that reduction of power does not necessarily decrease the operating range significantly. Therefore, the precise measurement of power is unnecessary. This is a false assumption. A change in the power output may result from altered operating conditions that are capable of causing an eventual equipment breakdown unless remedied. Additionally, power measurements are often the surest way of determining whether the overall performance of a transmitter is normal and in general accord with the specifications of the manufacturer.

In the MF to VHF range in communications, relative power output readings may be obtained from the front panel meters that are part of the equipment itself. These meters may be in the form of RF wattmeters or in the form of current meters and voltmeters in the final PA stage. Also, the transmitting antenna tuning unit normally has an RF wattmeter located on its front panel. Comparison between the transmitter and tuning unit wattmeters may reflect a difference between the output of the transmitter and the input of the antenna. When final PA stage voltage and current relationships are used, the formula for power ($P = IE$) must be used.

Another check for power output of some communications transmitters is obtained from direct readings of ammeters, calibrated to indicate power. This type of ammeter is connected in series with the antenna output terminals and will give an accurate indication only when the antenna impedance is at a value for which the meter has been calibrated. An application of this method is to substitute a dummy antenna for the antenna proper. If the meter is calibrated to indicate current or voltage, power can be accurately determined by the relationship: $P = I^2R$ or $P = E^2/R$, where:

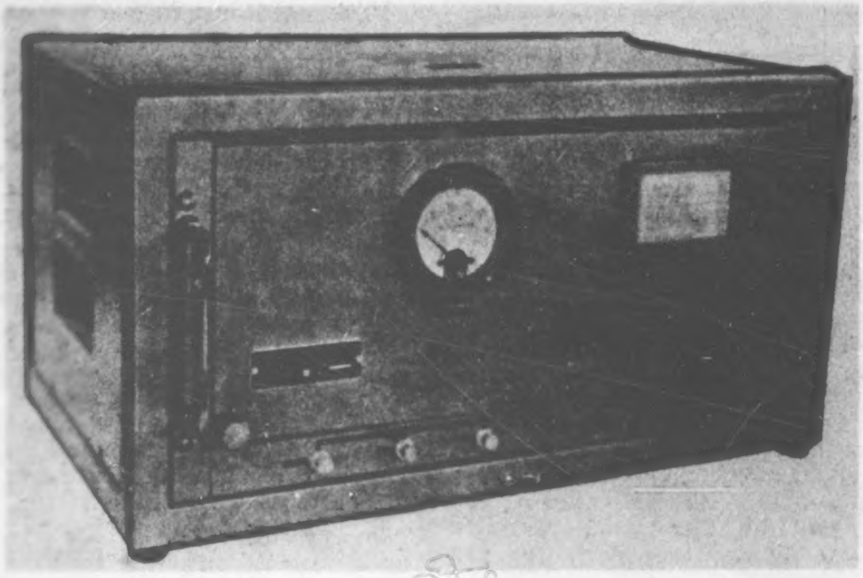
P = Power output

R = Resistance of the dummy antenna

I = Effective current

E = Effective voltage

Power measurements in the UHF and VHF ranges use indirect measurements. These methods normally convert RF energy into another form of energy, such as light or heat. (Direct



120.23

Figure 8-8.—AN/URQ-9 Frequency Standard.

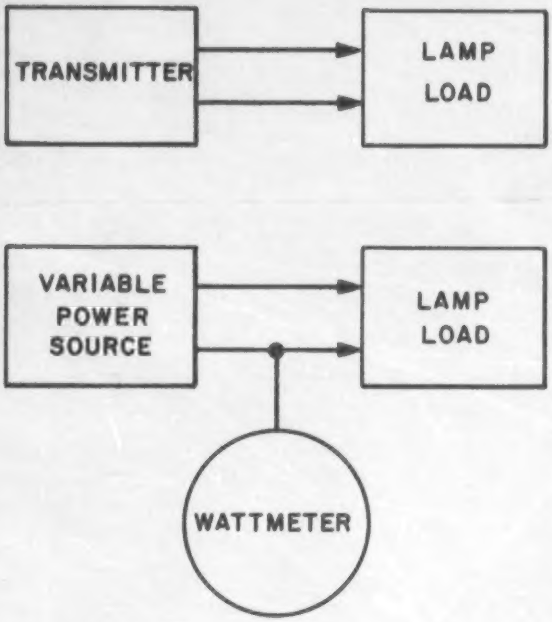
methods of measuring RF power are not effective at the higher frequencies.) One indirect method is the "lamp-load" method. This method involves the use of a series of incandescent lamps as a dummy antenna for the transmitter (see figure 8-9).

As power is applied from the transmitter, the lamp bank will begin to light brightly. An illumination meter is arranged so that it can measure the brilliance of the lamp bank. Then, the lamps are disconnected from the transmitter output and connected to a variable a.c. or d.c. power source. This variable source is used to light the same bank of lights to the same brilliance. A wattmeter may then be connected to determine the required power necessary to bring the lights to the same brilliance. This power is equivalent to the transmitter output. The impedance of the bank of lights should match the output impedance of the transmitter. Also, the wattage rating of the lamp load must be greater than the power being measured.

Transmitter Neutralization

Transmitters normally use rather large vacuum tubes in the RF amplifiers of the output stages. These vacuum tubes normally operate at a high level of efficiency and accomplish the desired result: Reliable communications. However, in every RF amplifier vacuum tube, an inherent problem exists that must occasionally be minimized. This inherent problem is known as "interelectrode capacitance". Interelectrode capacitance is the unwanted capacitive reactances caused inside the vacuum tube by the internal elements of the tube itself: The cathode, grid, and plate, as well as the other elements in multielement tubes.

As the operating frequency of an RF amplifier is raised, the interelectrode capacitance becomes large enough to cause a feedback signal that is degenerative in its nature. This degenerative feedback can reduce the effectiveness and efficiency of the amplifier tube and, therefore, the transmitter itself. The procedure used to correct this inherent characteristic of vacuum tubes used as RF amplifiers is known as "neutralization". Neutralization procedures are normally discussed and described in detail in the transmitter technical manual. There are any number of neutralization techniques involving just as many types of test equipments that may be



76.124
Figure 8-9.—Block diagram of lamp-load method of indirect power measurement.

used to carry out the process. These test specifications should be followed on a step-by-step basis; otherwise, the process will not be valid.

TELETYPE SYSTEMS TESTING

Teletype systems serving fleet and shore establishments include shipboard and station equipment operating in conjunction with wire or radio circuits or a combination of both. Comparatively simple facilities may be characterized as teletype circuits rather than systems when the teletypewriter stations are directly connected. A system is made up of numerous components, including station local lines, main transmission and retransmission circuits, multiplexing, terminal and repeating equipment, switchboards, and branch circuits extending to outlying localities.

Messages may be sent directly from a station to one or more distant stations over fixed circuits or over circuits involving one or more switchboards. Messages may also be relayed automatically, semiautomatically, or manually from one circuit to another, that is, received at an intermediate point and retransmitted to one or more points. Teletype circuits may also be used for interchanging information in a conversational manner.

Radio teletype systems involve a long series or chain of individual equipments, each of which must be kept at peak efficiency to produce satisfactory operation. Antennas and frequencies must be wisely chosen, receivers must be operating at peak efficiency and well tuned; and converters must be operating perfectly. Teletype transfer panels must be understood and adjusted for proper line conditions. Teletype machines must be kept in top mechanical condition.

Radio teletype has proven to be a time and labor saving device. The greatest speed is obtained by the use of tape transmission which provides a steady flow of message traffic at a constant 60 words (or more) per minute. This is far above manual circuit operator speed and capacity. As in other systems of message handling, standards of quality have been established to provide dependable service. The standard measure of message service quality is the number of errors per given period of time.

Radio teletype is subject to distortion due to propagation conditions. Weak and fading signals, however, may be copied with good quality by intelligent selection of antennas, careful attention to proper adjustment of receiving equipment, and correct usage of converter/comparator equipment. Teletype machine dependability is controlled to a great extent by the quality of the preventive maintenance applied.

Under favorable conditions and service, a steadily used machine should perform for six months or more without a breakdown. Normal wear to moving parts will eventually force the machine to fail if it does not receive an overhaul after this period of use.

Signals are produced by the operation of a teletypewriter keyboard similar to that of a typewriter, and the corresponding characters are typed in page form or on tape by printer mechanisms at both the sending and receiving stations. Signals may also be sent by the use of a punched tape prepared by another device called a "perforator" which has a keyboard that is also similar to that of a typewriter. Signals received from a transmitting station do not necessarily have to be printed in page form; they may be printed on a perforated paper tape by means of a typing reperforator. Some typing reperforators are furnished with a keyboard so that it may be used for the transmission of messages, especially for tactical communications. The paper tape is used to provide a communications teletype signal by feeding it through a device known to communications personnel as a "transmitter-distributor". The following is a discussion of basic teletypewriter testing.

Teletypewriter Operational Speeds

There are four common teletypewriter operational speeds which are expressed in words per minute (WPM) or operations per minute (OPM). The operations per minute are exact ratings since they are based upon the time intervals required to send the various intelligence pulses contained on a teletypewriter tape. The OPM are 368, 404, 470, and 600. Their corresponding WPM are 60, 66, 75, and 100, resepectively. Presently Navy teletypewriter equipment operates at speeds of 60, 75, and 100 WPM.

Teletypewriter Signals

Signals originated within the teletypewriter are transmitted in the form of d.c. pulses called "marking" and "spacing" impulses. Basically, a marking pulse occurs whenever current is flowing and a spacing pulse occurs whenever no current is flowing. The alphabet, figures, and functions of a teletypewriter correspond to a particular sequence of punched perforations in a teletypewriter tape. Therefore, whenever an operator depresses a teletypewriter key, a mechanical selection of punched perforations corresponding to that key is selected. Figure 8-10 shows a perforated teletypewriter tape corresponding to the various keys that may be depressed when a teletypewriter is operated. Also shown are the corresponding upper-case functions for communications and weather teletypewriters, (far-left of figure 8-10). Holes in the perforated tape correspond to marking impulses; whereas, no perforated holes correspond to the spacing impulse. As shown in figure 8-10, a 5-unit code is used for each character. For example, the letter "A" consists of two holes and three no-hole functions. Therefore, the letter "A" always has the first two units of the code perforated and the last three nonperforated. The small holes between the 2 and 3 units are "sprocket" holes designed to allow the tape to be mechanically fed through a transmitter-distributor. The length of time between each pulse is 22 milliseconds.

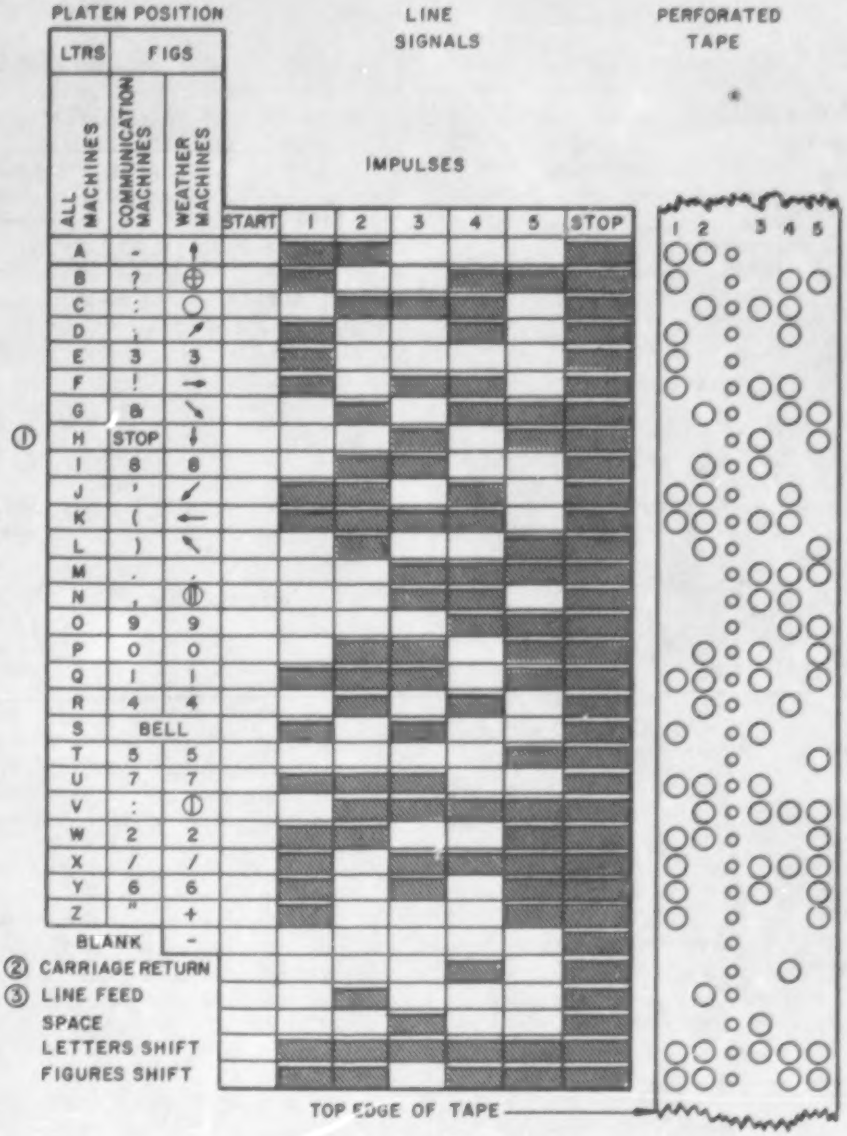
A further inspection of figure 8-10 reveals that two additional impulses are transmitted with each character. They are the "start" and "stop" impulses. Notice that the start impulse is always spacing (no-current is flowing) and that the stop impulse is always marking (current is flowing). The start impulse allows the relays in the receiving printing mechanisms to start translating the coded impulses at the same time that the transmitting mechanism sends the selected character. The stop impulse, on the other hand, ensures that all receiving mechanisms stop their mechanical operations at the same time that the transmitting teletypewriter has finished sending its coded signal.

Types of Transmissions

There are two general types of wire teletypewriter circuits: d.c. and carrier. The d.c. type of circuits are used for the shorter distances, including extensions within stations and branch circuits to outlying communications spaces. Carrier teletypewriter circuits generally comprise the transmission circuits for long and medium distance communications on land lines. Wire teletypewriter circuits generally will furnish dependable and accurate service if reasonable standards of circuit layout and maintenance are adhered to. Although radio transmission provides a high degree of flexibility for point-to-point communications from a station to any one of a large number of stations, wire teletypewriter circuits are overall more dependable because they are not subject to the variable conditions in the atmospheric medium and the possibility of accidental or intentional jamming. However, remember that wire-lines are impossible between fleet and shore activities. Therefore, radio-teletypewriter is more prevalent in naval communications than wire.

In radio teletype system transmission impairment may occur in the form of displacement marks and spaces (time distortion), in variations in strength of received signals, and in occasional obliteration of the received signals by interference. For operation in the HF

170


PLATEN POSITION
LINE SIGNALS
PERFORATED TAPE
IMPULSES
1 2 3 4 5
TOP EDGE OF TAPE

LTRS ALL MACHINES	FIGS COMMUNICATION MACHINES	FIGS WEATHER MACHINES	START	1	2	3	4	5	STOP
A	-	↑	☐	▨	▨	☐	☐	☐	▨
B	?	⊕	☐	▨	☐	☐	▨	▨	▨
C	:	○	☐	☐	▨	▨	▨	☐	▨
D	,	↗	☐	▨	☐	☐	▨	☐	▨
E	3	3	☐	▨	☐	☐	☐	☐	▨
F	!	→	☐	▨	☐	▨	▨	☐	▨
G	&	↘	☐	☐	▨	☐	▨	▨	▨
① H	STOP	↓	☐	☐	☐	▨	☐	▨	▨
I	8	8	☐	☐	▨	▨	☐	☐	▨
J	'	↙	☐	▨	▨	☐	▨	☐	▨
K	(	←	☐	▨	▨	▨	▨	☐	▨
L	)	↖	☐	☐	▨	☐	☐	▨	▨
M	.	.	☐	☐	☐	▨	▨	▨	▨
N	,	⦶	☐	☐	☐	▨	▨	☐	▨
O	9	9	☐	☐	☐	☐	▨	▨	▨
P	0	0	☐	☐	▨	▨	☐	▨	▨
Q	1	1	☐	▨	▨	▨	☐	▨	▨
R	4	4	☐	☐	▨	☐	▨	☐	▨
S	BELL		☐	▨	☐	▨	☐	☐	▨
T	5	5	☐	☐	☐	☐	☐	▨	▨
U	7	7	☐	▨	▨	▨	☐	☐	▨
V	:	⦶	☐	☐	▨	▨	▨	▨	▨
W	2	2	☐	▨	▨	☐	☐	▨	▨
X	/	/	☐	▨	☐	▨	▨	▨	▨
Y	6	6	☐	▨	☐	▨	☐	▨	▨
Z	"	+	☐	▨	☐	☐	☐	▨	▨
BLANK		-	☐	☐	☐	☐	☐	☐	▨
② CARRIAGE RETURN			☐	☐	☐	☐	▨	☐	▨
③ LINE FEED			☐	☐	▨	☐	☐	☐	▨
SPACE			☐	☐	☐	▨	☐	☐	▨
LETTERS SHIFT			☐	▨	▨	▨	▨	▨	▨
FIGURES SHIFT			☐	▨	▨	☐	▨	▨	▨

SIGNAL LENGTHS IN MILLISECONDS, STANDARD SPEED 60 WORDS PER MINUTE

|-22-|-22-|-22-|-22-|-22-|-22-|-31-|

☐ SPACING IMPULSES
▨ MARKING IMPULSES

① MOTOR STOP OPTIONAL ON WEATHER MACHINES
② < IS PRINTED ON TYPING REPERFORATORS
③ ≡ IS PRINTED ON TYPING REPERFORATORS

76.125

Figure 8-10.—Five unit start/stop teletypewriter code.

range over radio circuits using sky-wave transmission, it is generally desirable to use diversity operation. Thus, signals may be received simultaneously at two or more locations separated by several wavelengths (space diversity), or each signal may be sent and combined at the receiving station (frequency diversity). Where space is a limiting factor, two different adjacent antennas, such as vertical and horizontal, or differently oriented horizontals, may give some improvement by providing what is known as "polarization-diversity" reception.

The limiting length of a teletypewriter circuit, either wire or radio transmission, is considered to be that point at which a signal becomes so weak that it is incapable of actuating the receiving apparatus properly, when distortion of the teletypewriter pulses is excessive, or when the received signal strength is too low to override the interference. Usually, circuits are extended by inserting "repeaters" before the limiting length is reached. These repeaters automatically retransmit the received signals in practically perfect form if they have not suffered a large amount of distortion which would cause errors in the teletypewriter copy.

Basic Keyboard and Tape Transmitter Tests

Since all teletypewriters respond to the same functions and operations, they can all be tested for specific operations. However, you must bear in mind when performing basic checks that the response of the various units comprising teletypewriter systems is different from unit to unit for the same test or function.

Observation of teletypewriter equipment during operation is usually the first test performed on all units. For the keyboard, printer, and tape transmitter, transmitting with the receiver converter-comparator set on "tune" will provide a closed, continuous loop for testing purposes. A tape should be patched into the testing channel with the tape transmitter instead of using the keyboard. Tape transmitters generally operate at a constant 60 WPM and provide a more rigid test of the receiving printer.

Test tapes may be prepared on the keyboard of a reperforator machine and connected end-to-end with transparent tape to provide a continuous test signal. Many good texts are available for the test tape, the chief requirement being that it contains all the functions and characters used. The letters "R" and "Y" are commonly used as the test text because they require the selector unit to reverse all its code pulse components.

Using the keyboard of a teletypewriter is a good test but not a conclusive one. For example, if the motor of the machine is of the governed type, it will be possible for the speed of the motor to be too high or too low and still work with its own keyboard. Both are kept in synchronism by means of the main shaft gears. If a machine will not copy an incoming signal, check the machine first with its own keyboard. If it passes this test, try sending to it from another machine or tape transmitter known to be in good condition. If it passes this test, the machine is operating satisfactorily, and the incoming signal or the keyer in the converter is at fault. If it fails either test, the machine needs attention.

Range Selection

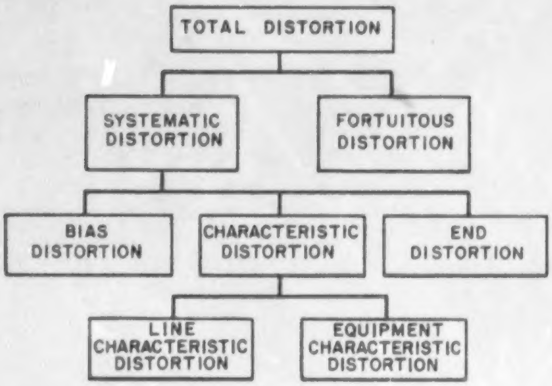
A good test for determining the "range" of a teletypewriter is performed with the letters "R" and "Y". The rangefinder pointer is always located on the front panel of the machine in clear view and marked. Alternately print the letters R and Y while slowly moving the rangefinder pointer toward the lower end of the scale until printing errors occur. Note the position of the pointer. Check the upper limit of the range by moving the rangefinder pointer toward the upper end of the scale until errors are printed. Note the position of the pointer again. Then set the rangefinder at the midpoint of these two extremes. Print the "test sentence" or text to check the selection process. The range under local test conditions with a well adjusted teletypewriter should be 80 points; however, a 70 point range is acceptable.

TELETYPEWRITER DISTORTION

Fundamentally, there are three types of distortion which adversely affect the fidelity of teletypewriter signals. These are bias, fortuitous, and characteristic distortion. Figure 8-11 illustrates these and other forms of distortion. They are defined as follows:

(1) Bias Distortion - The uniform lengthening or shortening of the mark or space elements, one at the expense of the other.

(2) Fortuitous Distortion - The random displacement, splitting, and/or breaking up of the mark and space elements.


TOTAL DISTORTION
SYSTEMATIC DISTORTION
FORTUITOUS DISTORTION
BIAS DISTORTION
CHARACTERISTIC DISTORTION
END DISTORTION
LINE CHARACTERISTIC DISTORTION
EQUIPMENT CHARACTERISTIC DISTORTION

76.126

Figure 8-11.—Components of Teletypewriter Distortion.

(3) End Distortion - A special type of telegraph signal distortion created for testing purposes. It has the effect of advancing or delaying the end of each marking impulse with respect to the beginning of the test cycle.

(4) Characteristic Distortion - The repetitive displacement or garbling peculiar to specific portions of a signal. There are two types of characteristic distortion. Line characteristic distortion and equipment characteristic distortion.

(5) Systematic Distortion - Periodic or constant distortion, such as bias or characteristic distortion, which is the direct opposite of fortuitous distortion.

(6) Total Distortion - The total of all forms of signal distortion is cumulative and is known as total distortion. A signal in one link of a teletypewriter transmission system may have one kind of distortion at that point and another kind of distortion in another link of the system. However, the signal could actually have less distortion at the distant receiving point due to the canceling effect of the various types of distortion upon each other.

You can determine the amount of distortion that the teletypewriter selector unit can tolerate by using a common signal distortion tester designed specifically for this type of test. If the test set or teletypewriter is equipped with governed motors, the motor speed must first be adjusted. The character selecting switch of the test set is set to transmit either "R" or "Y". The adjustable test set then is set to the desired percentage of bias and end distortion; this control is usually set for 35 percent.

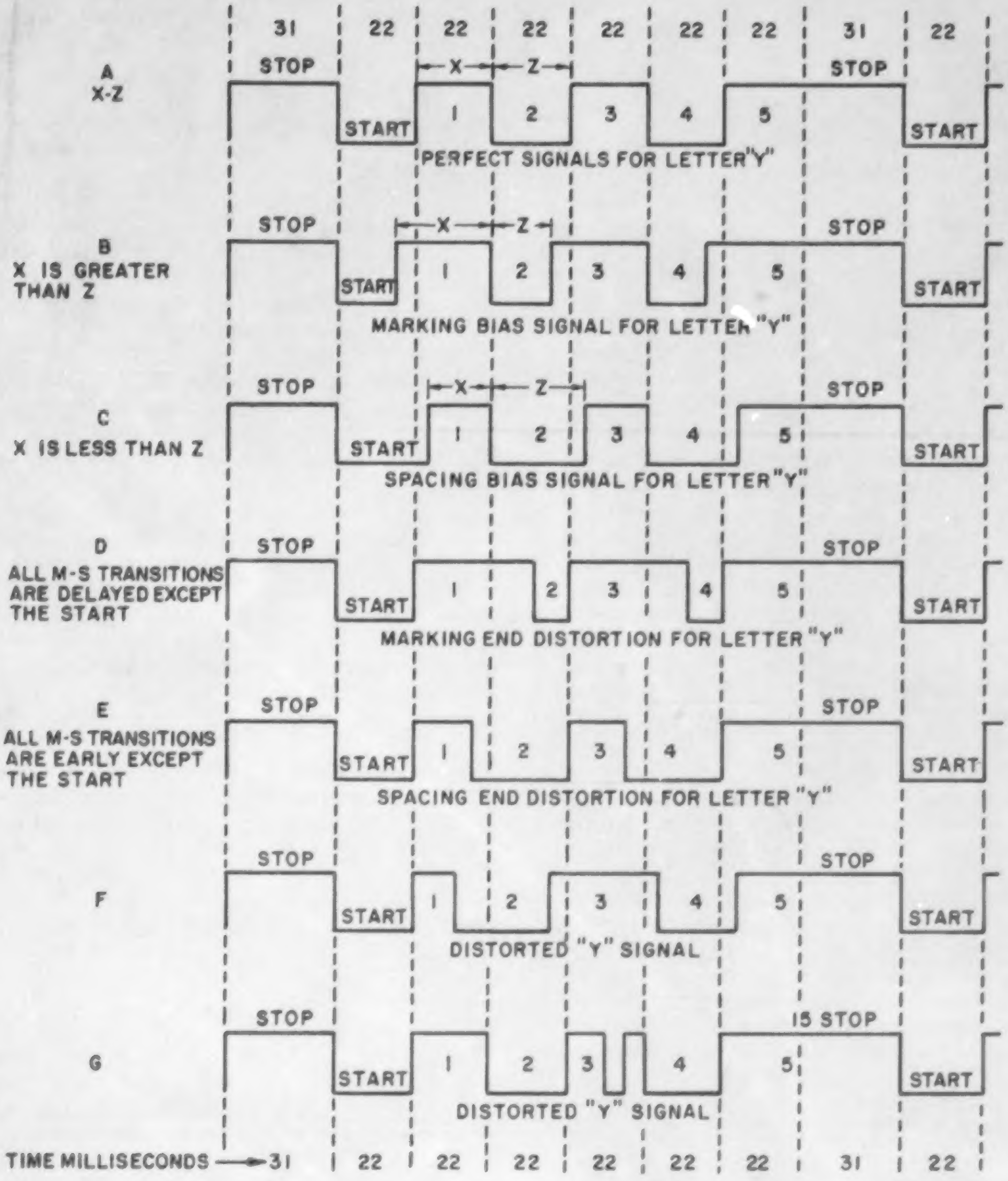
Causes and Effects of Bias Distortion

It is important that the radio operator or supervisor realize that bias distortion is the UNIFORM lengthening or shortening of the mark or space element, one at the expense of the other, as shown in figure 8-12, parts A through E. These show that the total time allocated to one mark and one space never changes, only the length of the mark or space element changes. If the mark is lengthened, then the space will be shortened by the amount that the mark is lengthened. If the above described distortion of the mark or space elements are not uniform and repetitive, some other form of distortion is taking place.

Bias distortion can change from one hour to the next or with one adjustment of the equipment to another; however, there are only a few places in a teletypewriter transmission system capable of producing bias distortion. A detuned receiver will produce either marking or spacing bias. In addition, any drift in the transmitter or receiver frequency control equipment may produce this distortion.

Changes in speed of sending equipment, though detrimental to the fidelity of the teletypewriter signals, cannot produce bias distortion even though certain types of distortion measuring equipment will indicate bias distortion when speed control is the real problem. Whenever transmission speed increases or decreases, the mark-space elements will be changed equally in length; therefore, the bias distortion could be zero but the total time for one mark and one space will be shorter or longer.

There are several ways of calculating bias distortion. The method most often used is the ratio between the normal mark or space and the amount the mark or space has been lengthened or shortened. This means that if the mark element is one-half longer than it should be, it would be considered a fifty percent (50%) marking bias; at the same moment, the space element would be shortened fifty percent (50%).


31
22
22
22
22
22
22
31
22
A
X-Z
STOP
X
Z
START
1
2
3
4
5
STOP
START
PERFECT SIGNALS FOR LETTER "Y"
B
X IS GREATER THAN Z
STOP
X
Z
START
1
2
3
4
5
STOP
START
MARKING BIAS SIGNAL FOR LETTER "Y"
C
X IS LESS THAN Z
STOP
X
Z
START
1
2
3
4
5
STOP
START
SPACING BIAS SIGNAL FOR LETTER "Y"
D
ALL M-S TRANSITIONS ARE DELAYED EXCEPT THE START
STOP
START
1
2
3
4
5
STOP
START
MARKING END DISTORTION FOR LETTER "Y"
E
ALL M-S TRANSITIONS ARE EARLY EXCEPT THE START
STOP
START
1
2
3
4
5
STOP
START
SPACING END DISTORTION FOR LETTER "Y"
F
STOP
START
1
2
3
4
5
STOP
START
DISTORTED "Y" SIGNAL
G
STOP
START
1
2
3
4
5
15 STOP
START
DISTORTED "Y" SIGNAL
TIME MILLISECONDS → 31
22
22
22
22
22
22
31
22

76.12

Figure 8-12.—Normal and distorted Teletypewriter Signal.

Causes and Effects of Fortuitous Distortion

Fortuitous distortion is caused by many things: Fading, multipath transmissions, atmospheric noise, power line induction, battery fluctuations, poorly soldered electrical joints, lightning, dirty keying contacts, and many other random disturbances.

Part F of figure 8-12 is an example of fortuitous distortion. Clearly, the various elements of the signal are not uniformly lengthened or shortened, as was the case for bias distortion. The displacement is random and uneven and will have no discernible pattern.

Causes and Effects of Characteristic Distortion

A definite amount of time is required for the line current to change from a marking to a spacing condition or vice versa, in a teletypewriter wire circuit. The time required sometimes is greater than the minimum time interval between transitions (the end of one character and the beginning of the next) in the signals. Some transitions then must occur while the current is still in the process of changing from the previous transmission.

Line characteristic distortion is basically the distortion caused when the length of the received signal impulses are affected by the presence of changing current transmissions in wire circuits. The amount of line characteristic distortion is dependent upon the magnitude of the condition. When the received impulses are shortened due to line characteristic distortion, the condition is known as "negative" line characteristic distortion. When the received impulses are lengthened due to line characteristic distortion, the condition is known as "positive" line characteristic distortion. This line characteristic distortion is sometimes revealed as marking or spacing bias on some distortion measuring equipment because it produces an effect similar to bias. The most reliable and effective way to eliminate line characteristic distortion in wire circuits is to operate the circuit with what is referred to as "polar" operation. In a teletypewriter circuit, this means that a marking impulse occurs whenever current flows in one direction and a spacing impulse occurs whenever it flows in the opposite direction. This minimizes the time lag due to the current to no-current transmission for marks and spaces. Instead, we have a current-to-current relationship, only of opposite polarity.

The contrasts between line characteristic distortion and the distortion caused by bias are as follows:

(1) The effect of line characteristic distortion depends upon the length of the impulses transmitted. The effect of bias is independent of the length of the impulses.

(2) For a given length of impulse, the effect of line characteristic distortion is independent of whether it is a marking or spacing impulse. The effect of bias is always opposite on a mark to what it is on a space.

(3) Line characteristic distortion is related to the amount and arrangement of the capacitance, inductance, and resistance of a wire circuit. Except in neutral operation, these factors do not affect bias.

(4) Bias is caused by unequal marking and spacing line current, conditions which do not affect line characteristic distortion.

(5) Line characteristic distortion normally varies only a small amount from day to day on a wire circuit. Bias may vary from hour to hour.

Equipment characteristic distortion is the repetitive displacement or disruption peculiar to specific portions of a signal and is normally caused by maladjusted or dirty contacts of the sending and receiving equipment. An example would be the repeated splitting of the third code element of a teletypewriter signal, illustrated in part G of figure 8-12.

It is important that a communications operator or supervisor be able to separate characteristic distortion from other forms of distortion. If it can be established that only a certain portion or portions of the signal is disrupted, he can immediately eliminate the entire system between the sender and receiver and know that the sending equipment is the cause of the distortion.

By comparing part A with part G of figure 8-12, it can be seen that the signal is suffering from a split element on the third code element.

If this happens repetitively, it would be classified as equipment characteristic distortion. If it happens only once over an extended period, it would be fortuitous distortion. On suitable distortion measuring equipment, part G would be displayed as two transmissions in this element; one approximately 50% late and another about 65% late. Equipment characteristic distortion can be introduced into a system at the sending end, repeating point, or receiving point.

Causes and Effects of Speed Problems

In start-stop teletypewriter transmission, there is the problem of synchronizing the speed of the receiving equipment with the speed of the sending equipment, character by character. It is for this reason that the teletypewriter stops at the end of each character. Many meter-type distortion measuring equipments will read speed problems as bias distortion; however, bias and speed distortion are two different entities. If a signal is caused to be sent at a faster or slower speed, it does not mean that the signal is biased. It means that the total time for one mark and one space is shorter or longer, but their mark-space ratio is unchanged.

Speed of teleprinter signals can be varied in several ways. The most common one is that the motor governor fails or is maladjusted. Speed variations can also be caused by slipping clutches on internal mechanical devices of the teletypewriter. The overall effect of off-speed operation in the start-stop teletypewriter transmission is to cause the later elements of the signal to be more distorted than the earlier portion of the signal.

Multiplex and Crypto Distortion

When more radioteletypewriter circuits are required than existing available frequencies allow, the additional circuits may be provided by using the principle of electronic time division multiplexing. The term "multiplexing" means the combining of several signals into one composite signal, transmitting it from one terminal to another, and then breaking down the composite signal into the original signals. The composite signal produced by multiplexing is often referred to as a MUX signal and multiplexing equipment as MUX equipment.

In the 60 WPM teletypewriter system, a conventional 7.42 unit code is used. To achieve this speed, the teletypewriter impulse shaft makes one complete revolution in 163 milliseconds to send one character. With each revolution, the start pulse and the five selecting pulses are 22 milliseconds, and the stop pulse is 31 milliseconds. If four complete characters are to be transmitted in approximately 163 milliseconds instead of just one character, the time required for each new character must be considerably shortened. This is accomplished by the MUX equipment, which compresses each transmitted character into a time period of 40 milliseconds. This MUX equipment accepts four 60 WPM teletypewriter channels, converts the intelligence received on each channel to a new 5-unit code (plus a sixth pulse) of shorter duration, and retransmits the total intelligence sequentially to a single wire or radio circuit.

At the receiving location, the MUX signal is applied to the receiving equipment which operates in synchronism or cycles at the same speed as the transmitter. It is essential that the signals be in phase; sometimes jump-phase effects produce distortion. When interference disrupts a received MUX circuit, all channels will be similarly affected. Difficulties experienced with an individual MUX channel cannot be attributed to interference. Therefore, unless the interfering signal is of a pulsing nature and identical in keying speed (synchronized) to that of the receiving MUX signal, all channels and not just one or two signals will be disrupted.

Scattered reflections of multipath propagation causes signal distortion and fading and generally have their greatest effect on MUX signals. The condition is normally of short duration, and no compensation or corrective action is required. However, the use of a frequency nearest the maximum usable frequency (MUF) will often help in offsetting the effects of this condition. Reduced channel operation will sometimes improve signal quality, but this should be done only as a last resort.

Cryptographic operation can be either synchronous or non-synchronous. Non-synchronous cryptographic operation depends on character count integrity, while synchronous cryptographic operation achieves character count integrity without requiring that each character transmitted is received. In non-synchronous operation, the same number of teletypewriter characters must be received at the distant end as were transmitted by the local transmitting equipment if the nonsynchronous equipments are to remain in the "SET" condition. The SET condition can be construed to be the "ready to operate" condition. A received teletype character may be garbled with no effect on this "SET" condition. This is called character count integrity and is a basic requirement to remain in the set condition. In synchronous cryptographic operation, the synchronous equipments will remain in set even if the teletypewriter character count is interfered with, since each of the synchronous equipments is kept in phase by its own frequency standard. The synchronous equipments do not depend upon the satisfactory transmission and reception of each character for their operation. To make certain the lines are satisfactory for use and that excessive distortion does not exist, bias and distortion checks are made, back-to-back circuits are used, and standard test tapes and proper procedures are used for online testing. Teletypewriter test sets are employed with self-contained oscilloscopes which measure the amount of distortion, line polarity, current, and speed so that all pertinent factors may be evaluated. Thus, the various types of distortion peculiar to teletypewriter equipment can be measured without interrupting service on start-stop synchronous teletypewriter signals.

MUTUAL INTERFERENCE PROBLEMS

In a communications system, the number of radio circuits employed may necessitate the use of many transmitters and receivers in the same general locality. The selection of frequencies to avoid mutual interference between communication equipments becomes increasingly more complex as the proximity and/or number of equipments is increased. While it is possible to reasonably estimate the frequencies at which interference is likely to occur, it is impractical to try to accurately predict the seriousness of interference at specific frequencies. The information given in the following paragraphs will aid you in your knowledge of basic interference problems and logical means of reducing them.

Transmitter-To-Receiver Interference

Transmitter-to-receiver interference is a major type of interference that is difficult to avoid aboard ship and in any area where many transmitters and receivers are located in proximity to one another. Additionally, signals arriving at a receiver from a distant transmitter are usually weak and can be interfered with easily by nearby transmitters.

Every transmitter radiates small amounts of energy at many frequencies other than its fundamental carrier frequency, and each receiver is responsive to signals of many frequencies other than the desired strong signals from two nearby transmitters operating on different frequencies may heterodyne in a receiver to produce interference. These spurious radiations and responses greatly increase the number of frequencies at which interference can occur. For example, when transmitting and receiving antennas are located close together, interference may result, not only in receivers tuned to frequencies near that of a strong transmitter carrier but also in receivers tuned to frequencies corresponding to the weaker spurious transmitter radiations.

Antenna Location

Much of the interference that occurs when transmitting and receiving antennas are located close together disappears when the intensities of interfering signals are reduced by simply separating the transmitting and receiving antennas. Another method of reducing interference at shore communication stations is to provide separate sites for transmitting and receiving antennas. Separations of as much as 5 miles are not uncommon where transmitter outputs of 400 watts and above are involved.

Mutual interference can exist between communication equipments operating in widely separated frequency bands if these equipments are in close proximity to one another. For example, high-frequency transmitters emit spurious radiations at many times the assigned operating frequency, and these radiations may cause interference in very high frequency receivers located nearby.

As an alternative to space attenuation by means of antenna separation, the directional characteristics of antennas are used to advantage in reducing mutual interference. Also, where the transmitting and receiving antennas are located near each other, consideration is given to the usage of ship structures or the natural contours of the area to provide antenna isolation. "Terrain shielding", as it is called, is satisfactorily employed in many locations aboard ship where the orientation of the antenna radiation patterns permits such an arrangement.

When space is not provided to separate transmitting and receiving antennas, as aboard ship or with mobile equipment, for example, certain types of interference cannot be so easily eliminated. With numerous transmitting and receiving antennas separated by only a few hundred feet or so, the number of interference possibilities increases to such an extent that the solution of the operating frequency assignment problem becomes very difficult. If such a situation cannot possibly be avoided, it is then essential to understand the equipment characteristics responsible for the interference. This will aid in selecting initial operating frequencies that will have some prospect of reasonable success when operations are begun.

Spurious Transmitter Radiation

Spurious transmitter radiations account for much of the transmitter to receiver interference when transmitting and receiving antennas are located in close proximity to each other. Most of the power in the output of a transmitter is in the operating carrier frequency and the sidebands. However, a small amount of power is always present at the self-generated frequencies that are exact multiples of the fundamental frequency (harmonics). Harmonic radiation is undesirable from the interference standpoint, as well as the power loss and lowered efficiency as a result of them. The design of a transmitter usually incorporates features which help to eliminate, or at least suppress, these harmonics.

Because of possible harmonic radiation from transmitters, guy wires which support antenna masts should be divided into insulated sections, the lengths of which are not harmonically related to the operating frequency. Failure to observe this practice leads to re-radiation of spurious harmonics from the length of the guy wire.

Since the frequencies of these spurious outputs are different for different operating carrier frequencies, it is apparent that the number of receiving channels which may be interfered with increases with the number of transmitters in operation, as each transmitting frequency will be accompanied by a series of spurious radiations. Spurious transmitter radiations can also be caused by cross modulation between two transmitters.

Cross Modulation

When an undesired signal feeds through into an operating circuit so that it interferes with the circuit or modulates it with interference, the effect is known as cross modulation. Cross modulation also results when two transmitters are very close together. When the antennas or transmission lines of two transmitters are located near each other, RF voltage from one transmitter may be impressed across the output of the other.

Interference of this type should not prove serious if the receiving antennas are well separated from the transmitting antennas, since the spurious frequencies are highly attenuated. Another method of reducing cross modulation is by separating the transmitting antennas themselves, one from the other. The same applies for the receiving antennas. Also, reorienting transmitting antennas so as to take advantage of their directional characteristics and radiation patterns helps reduce cross modulation.

Receiver-To-Receiver Interference

Spurious receiver radiations account for much of the receiver-to-receiver interference. This type of interference is not usually serious but must sometimes be considered in situations where receiving antennas are closely grouped or when receivers are connected to a common antenna. Almost without exception, communication receivers are of the superheterodyne type. The fundamental or harmonic frequencies of the local oscillator in one receiver may reach the input of a nearby receiver through several signal paths, the most important of which is probably through coupling between the antennas used in conjunction with the receivers.

In some cases, several receivers operating on different frequencies may be connected to a common antenna in which case suitable isolation between the receivers must be provided, or the operating frequency of each receiver chosen so that local oscillator radiation does not present an interference problem. A multi-coupler is often used to reduce the effect of local oscillator radiation and afford some isolation of the several receivers.

Reduction of Transmitter Radiation

In checking for transmitter radiation, the only really satisfactory indicating instrument is a sensitive receiver or a panoramic adapter. A panoramic adapter is a test instrument similar to a spectrum analyzer that can visually indicate existing sidebands or interference around a carrier. Radiation checks should be made into a dummy load of the proper power and impedance rating and should be made on all frequencies that are to be used in transmitting.

Naturally, the reduction of unwanted transmitter radiation can be best accomplished through proper design procedures. One of the preventive measures considered very important is the effective "shielding" of components and stages within the transmitter. To be effective, a shield must completely enclose the circuit or stage. This total enclosure may be a physical or electrical one. That is to say, shields may be in the form of a metal box enclosing certain components, or they may be in the form of an electrical potential designed to counteract a tendency of the circuit to radiate minute portions of RF energy from its components. Unfortunately, ordinary metal boxes and cabinets do not provide total shielding, since such openings as lids and holes for running connections allow leakage.

A primary requisite for good shielding is that all joints must make good electrical connection along their entire lengths. A small slit or crack will emit a surprising amount of RF energy; so will holes; such as those used for mounting meters. On the other hand, small holes do not impair the shielding greatly, and a limited number of ventilating holes may be used if they are small (not over 1/4 inch in diameter).

Most wires used in transmitters today employ shielded wires between power supplies and components and at all connections where practical. A shielded wire is simply one that has a "braid" inside the outer jacket to provide a means of preventing spurious radiations due to skin effect and to enable a ground potential to be placed at each end of it. For example, the wires used to connect a.c. or d.c. to the socket connections for a vacuum tube are normally shielded by connecting the braid of the wire to chassis ground at each end of the wire run, and at various points in between. Meters are normally enclosed in shielding covers, the meter connections being made with shielded wire. RF cable and control cable runs are normally made with high quality shielded cables, thus preventing inductive interference with other cables in close proximity.

ANTENNA FIELD STRENGTH MEASUREMENTS

Field strength is the effective value of the electric field intensity and is measured in microvolts or microvolts per meter. Field strength measurements are normally taken only from one particular side of an antenna. Thus, the only way to estimate overall antenna field strength is to take a series of measurements at four points and average them out. The four points would be made at the front, back, and two sides of the antenna, giving you an omnidirectional average of overall field strength.

The field strength produced by an antenna is proportional to the current flowing in it. Those parts of the antenna that carry the most current, as a result of standing waves, have the most radiating effect. Field strength measurements should not be confused with directivity and gain measurements. Although they are closely linked and each affects the other, they are measured differently and mean different things. The directivity of an antenna is determined from an aggregate collection of data from all points of the antenna, giving us a general picture of the way in which the antenna radiates the RF energy fed to it. The power gain of an antenna is the measurement of the directivity of the antenna under test as compared to that of an ideal (isotropic) antenna.

When making these measurements, many different types of test equipments are available in different ranges of frequency coverage. These radio test sets, field strength meters, and radio noise meters can be used to measure either relative or absolute magnitudes of field intensities produced by an excited transmitting antenna. The information obtained from field strength measurements can be used to determine antenna efficiency, directivity characteristics, and spurious radiations. When you use field intensity measuring equipment, you must remove objects or persons near the radiating source or the meter because they will cause reflections which result in erratic meter readings.

SINGLE SIDEBAND (SSB) TESTING

Transmitter output monitoring and accurate transmitter frequency adjustment are even more important in SSB than in AM applications. Not only must the SSB transmitter be adjusted to operate within tolerances specified by the using services, but it must also be adjusted to operate within its own strict tolerances because intelligibility of the reproduced SSB message depends upon such adjustments.

Methods used for testing or performing preventive maintenance on an SSB transmitter will vary slightly for different equipment applications. For example, some installations have special test units incorporated into the overall system configuration. These test units, often referred to as "distortion measuring equipment", are usually designed for the specific applications where used and provide a means for making such measurements as distortion, gain, frequency response, noise, and modulation level. If no such equipment is provided, suitable individual test equipment (signal generators, voltmeters, oscilloscopes, etc.) can be used for making the test or performing the PM. The following is a discussion of SSB testing.

RF Carrier Oscillator

In Single-Sideband Suppressed Carrier (SSSC) systems in which no carrier is transmitted with the signal, a carrier is inserted at the receiver to correspond to the one suppressed at the transmitter. This locally generated carrier must be at exactly the same frequency as the carrier that was suppressed in the transmitter if the demodulation process is to be performed properly. Consequently, for proper operation of an SSSC system, the local carrier oscillators in both the receiver and the transmitter must operate at the same frequency at all times. Therefore, the importance of stability and accuracy of frequency adjustment of the local carrier RF oscillator or its equivalent circuit cannot be stressed too strongly. Normally, preventive maintenance checks are mandatory to ensure the proper operation of the carrier oscillator and associated circuits.

When performing PMs concerning frequency of the carrier oscillator, an extremely accurate signal generator or direct-reading frequency meter can be used. To properly check and adjust this circuit, it is necessary that the accuracy of the test equipment equal or, preferably, exceed the accuracy of the circuit being tested. Some of the signal generators and frequency meters used in AM applications do not meet the strict requirements of single-sideband systems. Test equipments and instruments specifically designed for single-sideband applications should be used whenever available. Also, sufficient warm-up time should be allowed for all test instruments to ensure stable operation.

Whenever checks show that the carrier oscillator is in error, the first step in correcting the situation is to check and adjust the regulated voltages that are applied to this circuit. This can usually be accomplished through the use of screwdriver adjusted rheostats or potentiometers located in and around the carrier oscillator circuit. Accurate voltmeters should be used to make these voltage checks and adjustments. Incorrect voltages applied to this circuit are a major source of oscillator frequency errors. Whenever a tube change is made in the oscillator circuit, the voltages should again be checked and adjusted to the recommended values.

After the applied voltages have been adjusted, the frequency of the oscillator can then be properly adjusted. This is always done in accordance with technical manual and maintenance standards manual instructions. The final adjustment to carrier oscillators is normally the setting of the output signal voltage to the level prescribed by the equipment manufacturer. Precautions stressed in the technical manual should be strictly observed for proper adjustment of the RF carrier oscillator.

Balanced Modulator Adjustments

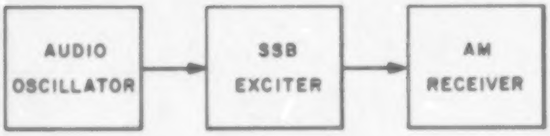
The primary purpose of any balanced modulator circuit is to produce the sidebands of the RF carrier and to suppress or reject the carrier. Most balanced modulators are designed and adjusted to achieve a carrier suppression of approximately 35 to 40 dB. If a carrier is transmitted with the SSB signal, its level is normally reduced 10 to 20 dB below the level of the sideband signal.

A certain degree of balance is "built-in" to a balanced modulator circuit by the equipment design. This involves the choice of tubes, components, and circuit arrangement. To compensate for changes in values of components due to environmental and operational conditions, separate balance controls are usually incorporated into the transmitter. These controls are usually very easy to reach when necessary in performing PMs and making minor adjustments.

The first step in adjusting a balanced modulator is to check the circuit operating voltages. Normally, this can be accomplished through the built-in test jacks or through front panel meters designed to indicate the various basic operating voltages associated with that circuit. If vacuum tubes are replaced in the balanced modulator circuit, care should be exercised in determining that the replacement tube matches exactly the tube removed. This may sometimes necessitate a basic realignment of circuits in SSB equipment.

Basically, carrier balance can be adjusted by applying a test tone from an audio oscillator to the SSB exciter circuit (usually located very near the balanced modulator proper) and coupling an AM receiver to the output (as shown in figure 8-13). The test tone coming from the oscillator should be very stable and distortion free with a means of controlling its frequency and amplitude. Any suitable AM receiver with the proper frequency range can be used.

After a sufficient warm-up time, the carrier-level control of the receiver should be turned to its minimum position so that no carrier is applied to the signal through carrier-reinsertion circuits. A suitable test tone is then applied to the exciter. If the balanced modulator is unbalanced, the AM receiver should be able to receive the signal. The "balance" control is then adjusted for minimum tone output from the receiver. This is normally a very simple adjustment and should be done in accordance with step-by-step procedures contained in the equipment technical manual.



76.128

Figure 8-13.—Basic equipment setup for carrier balance adjustment.

Sideband Filters

The purpose of the sideband filters in an SSB transmitter is to pass only the desired band of frequencies with a minimum of distortion and loss. Filter characteristics are determined primarily by the filter design and are usually permanent once the initial design is completed. Not only is it desirable to pass a certain band of frequencies, but it is equally important that all frequencies outside this desired band be attenuated sufficiently so that they do not appear at the output of the transmitter. This is very important in dual-channel SSB systems where two intelligence signals are transmitted on opposite sides of a suppressed, or reduced, carrier.

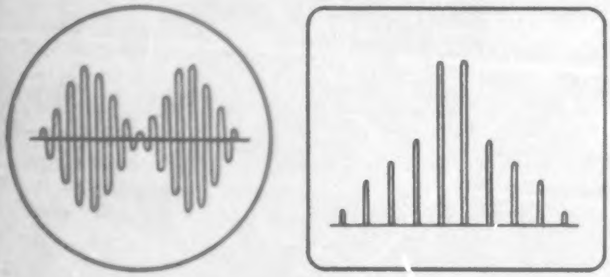
As a general rule, the communications operator should not attempt to adjust sideband filters. The necessary features are made and sealed in during the construction of most filters, especially mechanical ones. Attempts to adjust mechanical filters should not be undertaken under any conditions. Crystal filters may be adjusted by technicians only; no operator should attempt to perform these adjustments.

The importance of the sideband filters in regard to the over-all performance of a single sideband transmitter cannot be overstressed. Therefore, strict adherence to the technical manual's instructions concerning sideband filters is essential. Normally, sideband filters should simply be replaced by the operator if doubt exists as to their usefulness.

"Two-Tone" Testing In SSB

The most widely used method of testing SSB transmitters is the "two-tone" test. This test involves the application of two separate tone signals to the input of a system or circuit and observing the results on an oscilloscope, spectrum analyzer, or some other indicating device. The two tones should be equal in amplitude and have a difference in frequency of about 1000 Hz. Typical examples of two-tone waveforms during test are shown in figure 8-14.

This test, often an SSB PM, can be performed using either an RF or audio oscillator, whichever is applicable to the test being performed. Basically, what is done is that two test signals are applied to the transmitter input. The balanced modulator is deliberately slightly unbalanced to allow a portion of the carrier to "feed through". Care should be exercised to ensure that the



TWO-TONE TEST OBSERVED ON OSCILLOSCOPE (A)

TWO-TONE TEST OBSERVED ON SPECTRUM ANALYZER (B)

76.129

Figure 8-14.—Examples of ideal two-tone waveforms during test.

amplitudes of the two tones are maintained constant. Upon completion of the two tone test, the carrier balance should be reset and adjusted to ensure that it is at the proper point for operation of the equipment.

SSB Signal-To-Noise Measurements

The signal-to-noise ratio, usually given in dB, is defined as the value of the signal to the value of the noise in a particular application and is generally a function of the bandwidth of the overall transmitting system. In cases where impulse noise is to be measured, the ratio is usually expressed in terms of peak values. In random noise measurements, root-mean-square values are used.

To determine the signal-to-noise ratio of a system, it is necessary to measure the output of the system, using an output indicator both with and without a test tone. In all cases, the equipment technical manual should be consulted for the exact procedure to use in checking a particular system.

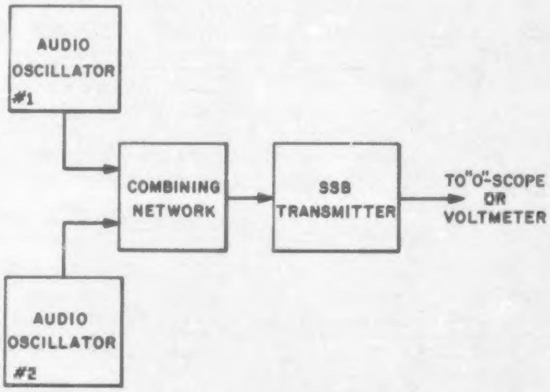
Peak Envelope Power (PEP) Measurement

There is a direct relationship between the maximum power output of a transmitter and the amount of distortion that is permissible in the system. For this reason, the power output rating of a transmitter is usually given in terms of the maximum power that can be delivered with respect to a specified amount of distortion that can be tolerated. If no value of distortion is specified, it is understood that the distortion will be kept within limits considered to be acceptable for the system.

The power output of an SSB transmitter is usually given in terms of peak envelope power (PEP). Peak-envelope power is equal to the sum of the amplitudes of the sideband components and the pilot carrier. The measurement of PEP is usually made using the two-tone test procedure with the carrier turned "ON". Figure 8-15 shows one method of measuring the PEP of an SSB transmitter. If an oscilloscope is used, the reading sought is normally peak-to-peak. If a voltmeter is used, the reading sought is normally root-mean-square (rms).

Another rating sometimes given to SSB transmitters is called "peak sideband power, (PSP)". It is similar to peak envelope power except that the measurement of this power is made with the carrier turned "OFF". In this way, the transmitter power is applied to the sidebands and none is applied to the carrier.

"Talking Power" is a term also often used in reference to SSB transmitters. Talking power is defined as the portion of the transmitter output that carries the intelligence of the message. Since only the desired sideband is radiated in SSSC systems, the talking power and peak sideband power of such systems are closely related. As the carrier suppression increases, the amount of available sideband power (and



76.130

Figure 8-15.—Basic equipment setup for measuring Peak-Envelope-Power (PEP).

the talking power) will increase. If the carrier is suppressed completely, the total output of the transmitter will be applied to the sideband signal. Therefore, complete carrier suppression in SSSC is desirable.

SSB Transmitter Monitoring

Transmitter monitoring simply means the checking of a transmitter to determine the quality of its transmission. Some transmitters have separate monitor panels or units built into the system to provide a continuous check of the transmitter while it is in operation. The monitor panel, or unit, samples voltages or currents at different points in the transmitter to ascertain that particular circuits are functioning properly.

Often, preventive maintenance checks require the use of built-in or front panel meters and monitoring units. Other times, test equipment is necessary, used separately. To prevent potential hazards and equipment damage, it is important to observe all precautions pertaining to test equipments, especially oscilloscopes, because of the high voltages present in all transmitters.

SSB Receiver Maintenance Techniques

Proper preventive maintenance and basic tests and adjustments of a single-sideband receiver should include the use of test equipment designed for the purpose whenever possible. If this is not possible, test equipment should be used with an accuracy equal to, or exceeding, the accuracy to be maintained in the receiver.

Two factors must be borne in mind in the choice of test equipment for preventive maintenance or basic adjustment of SSB receivers:

(1) The close tolerances required of the receiver oscillator frequencies.

(2) The sharp bandpass of SSB receivers.

Signal generators designed for single-sideband applications are presently in use and available in every work center. Barring their availability, frequency meters or standard reference oscillators with a known accuracy may be used for basic adjustments. The reference used should have an accuracy at least equal to, or greater than, the circuit to be adjusted in the SSB receiver. Preferably, the accuracy of equipment used to adjust receiver oscillators should be greater than ten-to-one.

COMPUTER EQUIPMENT TESTING

More and more, computerized equipments are being utilized in communications systems both afloat and ashore. Automated and satellite communications systems are relying more heavily on computers at each stage of development. Naturally, with the advent of these more complex and exacting equipments, maintenance and proper upkeep requirements increase in importance. Therefore, a basic knowledge of computer types and simple block functions becomes necessary in order to obtain "ground-level" information about the equipments that we will be using as advances are made.

Computer Types

A computer may be a small unit consisting of a few circuits, or it may be a large complex equipment involving thousands of circuits. There are two general types of computers:

(1) Digital

(2) Analog

The digital computer performs mathematical operations by a process known as "repeated addition". The analog computer may use any one of several methods, but it is not considered as overall accurate as the digital type. Large computers which require a high degree of accuracy are normally of the digital type.

Analog Computers

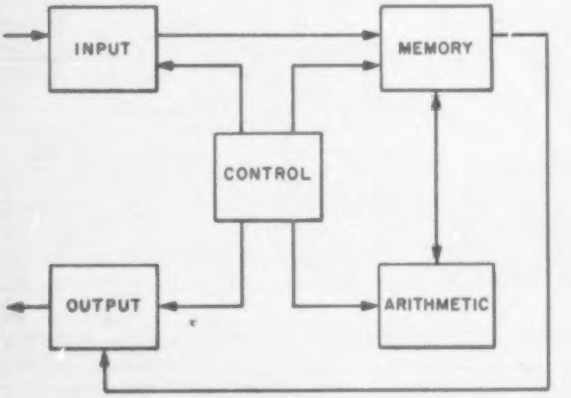
Analog computers are used primarily for such applications as determining the altitude of targets that are detected by radar equipment and solving specific types of mathematical equations for design calculations. Such computers are usually composed of summing, multiplication, differentiating, and integrating circuits. Although analog computers are not considered accurate enough for many applications, they are capable of utilizing voltage and current values and changing those values into digital form. Conversely, analog computers may use these values in digital form and convert them into voltages or currents to operate front panel controls and indications. Naval communications systems utilize digital computer circuits more than analog.

Digital Computers

The basic sections of a digital computer are shown in figure 8-16. These block representations perform the input, output, memory, arithmetic, and control functions. All data enters the computer through the input section, where it may be converted to a digital form and placed in a storage device. The memory section accepts this data at specific intervals and places it in the proper storage location. Two paths lead out of the memory element: One to the control section and one to the arithmetic section. Instructions are transferred from the memory to the control section, in which they are decoded and certain commands are set up for operation of the computer.

Input

The input section accepts information in various forms and converts it to a form which can be used by other sections of the computer. Input information is applied to computers by many different methods: punched card readers, magnetic tapes, paper tapes, typewriters, teletypewriters, and radiotelephones.



76.131
Figure 8-16.—Block diagram of basic digital computer.

Control

The control section generates signals at the proper time to cause a desired action to take place within the computer. This is normally accomplished by decoder and other switching circuits and devices. The control section keeps track of the instructions that are to be decoded and may perform part of the decoding. In addition, this section synchronizes all sections of the computer.

Memory

The memory section stores information until it is needed by one of the other sections of the computer. Memory devices are assigned "addresses" and the appropriate address is specified in the computer signal when information is needed or is sent to be stored. It is from this section that stored information such as that used in the Navy AUTODIN system is recalled.

Arithmetic

Addition is the basic operation of the arithmetic section of a digital computer; other arithmetic functions are simply variations of the addition function. For example, multiplication in the arithmetic section is simply a repetitive addition. The arithmetic section is used to store or transfer the results of a computation.

Output

The results of the computer operation are fed to the output for either local or distant applications. Some examples of output units are teletypewriter line printers, card punchers, and magnetic tapes such as those used in the Navy AUTODIN communication system, paper tapes, frequency counters, cathode-ray tubes, and radiotelephone secure systems. In other words, the output of a computer may vary widely, depending upon its use and what it has been "programmed" to do.

COMPUTER QUALITY ASSURANCE TECHNIQUES

To meet reliability requirements and provide efficient operation, special preventive maintenance techniques have been developed for large and small computers. Most maintenance for computer circuits involves the simulation of actual data fed to the computer itself, very much like

184

the tests that are performed on teletypewriters with test tapes. Naturally, the type of test determines the type of quality assurance information fed to the circuits for internal circulation. There are also "marginal checking" circuits in digital computers. These types of circuits are included in computers to detect aging of circuit parts before failures occur. This is a valuable preventive aid that is not provided in normal, non-computerized equipments.

Digital computers as well as analog computers may be "programmed" for checks. These programs provide an overall check of all computer circuits. In addition to these special techniques, normal preventive maintenance procedures can be carried out in accordance with proper instructions with available test equipments carried for that specific purpose.

Basic Programs

A "program" is a series of instructions which control the operations of a computer. Each instruction is used to cause some action which is a part of the overall task that the computer must perform. Therefore, an instruction may be considered to be the basic building block of a computer program.

An efficient program makes full use of the instructions which are available to accomplish the task in the shortest possible time and uses the least number of instructions. Computer programs are usually developed according to "time" or "number". In other words, if time is important, maintenance and quality assurance programs normally use instructions of short duration utilizing many checks. On the other hand, if time is relatively unimportant, maintenance programs normally do a great number of things and cause the computer to run through the same program more than once.

Maintenance Programs

A maintenance program provides a thorough and rapid method for the detection of failures in a special section of the computer. This type of overall maintenance check is very flexible and efficient. A program can be changed when the computer or auxiliary components are changed, and the program can be constantly improved. Normally, no extra test equipment is required since the computer circuits are used to perform the test. Testing by means of a maintenance program also results in the computer circuits being used in a more normal manner than when test equipments are used.

Maintenance programs are divided into three main classes:

(1) Reliability
(2) Diagnostic
(3) Utility

Maintenance programs that are used to detect the existence of errors are called reliability programs. Reliability programs should be arranged to check as many computer circuits as possible.

Maintenance programs that are used to locate the circuits in which computer malfunctions originate are called "diagnostic" programs. An effective diagnostic program locates the source of trouble as closely as possible. Actually, in many cases, reliability programs have diagnostic features, and diagnostic programs have reliability features. For convenience, a program is called either a reliability or diagnostic program depending on its intended emphasis.

Utility programs are used as aids for both operational and maintenance programming procedures. This type of program is used to print out information from storage devices within the computer memory section. It is also used to transfer maintenance programs into the computer memory section.

Reliability Programs

Reliability programs are used in both preventive and corrective maintenance tests to detect circuit failures rapidly and to discover failures that may occur only under particular operating conditions. In order to detect such failures, it is necessary to use reliability programs which check logical operation, paths of information flow, ability of a computer to perform all functions, execution of instructions, etc.

Reliability programs check either the logical functioning of an entire computer section or the logical functioning of individual circuit groups within a section. Whichever method is used, it is assumed that associated circuits which were not directly checked by the program are in satisfactory operating condition. Thus, these programs can be considered to fall into two categories: First order and second order. First order reliability programs check the operation of an entire computer section, while second order programs check the operation of assemblies or circuit groups. In most cases, first order programs are merely a combination of several second order programs.

A reliability program provides a good or bad indication regarding the ability of the tested computer section or circuit to perform its operating functions. In the event of a failure indication, the failure may be in the area being checked or in another area that has been assumed trouble free. Diagnostic maintenance programs should then be used to locate the source of trouble.

Diagnostic Programs

To be efficient, maintenance programs for diagnostic applications must enable you to narrow the area of the problem down to the smallest area or number of circuits. This is done by employing the following area checks:

(1) Increasing area
(2) Decreasing area
(3) Overlapping area
(4) Large area

The most effective method will depend upon the particular type of computer being tested.

A maintenance program using the increasing area check initially tests a small number of circuits. If a check indicates that all tested circuits are operating properly, successive checks are run in which progressively greater numbers of circuits are added. By this method, circuits which are found to be operating correctly are used to check other circuits. This process is continued until all circuits that can be checked by a maintenance program have been tested.

A decreasing area check is used by initially checking a large number of circuits with the maintenance program. If trouble is detected in a large area, additional checks are made of successively smaller portions of the equipment until the stages affected by the failure are not included in the test area. You are then able to determine the defective stage. If the check of a large area reveals no error, the remaining large areas of the equipment are checked until the trouble is detected. In many cases, trouble can be located more rapidly by this procedure than by the increasing area method.

The overlapping area check is an efficient method of locating trouble within a small section of the equipment. The routines of this type of maintenance program overlap each other. Thus, a failure is located at the overlapping portions of the routines which indicate the presence of trouble.

A large area check is used whenever an effective maintenance program for some small sections of a computer cannot be developed. A maintenance program can then be used only to detect the general area in which the malfunction occurs. When the general area is located, conventional troubleshooting by qualified technicians will be necessary to find the circuit in which a failure has occurred.

"Halt" Instructions

The "halt" instruction causes the computer to stop executing instructions under program control. However, any operation which is in progress at the time the halt instruction is decoded will be completed first. For example, if information is being read into the memory from a deck of punched AUTODIN cards, all cards will be read before the computer halts, even if the halt instruction was issued just after the reading operation began.

Clear and Add Instruction

The clear and add instruction is used to enter a quantity from the memory section without changing the sign or magnitude of the words. This instruction is normally used when it is desired to begin a type of addition problem. It clears the necessary circuits and transfers the necessary information according to address, and the addition is accomplished in the proper section of the computer.

Add Instruction

This instruction is similar to the clear and add instruction except that it does not provide for clearing the circuits before the addition process begins. It should be noted that the add instruction can cause an overflow if the numbers added together are sufficiently large. If this happens, the result in the final analysis, is meaningless.

Full Store Instruction

The full store instruction is used to transfer information into the memory area specified by the address portion of the instruction. Thus, the results of any operation performed by the arithmetic section are placed in the memory section for future use.

DIAGNOSIS AND ASSURANCE LOGIC

The basic element, so often overlooked in many areas of system diagnosis and quality assurance, is a logical approach. The term logic simply means "the system or principles of reasoning applicable to any branch of knowledge or study". That is to say, besides the absolute precautions and procedures applicable to preventive maintenance, system troubleshooting, or corrective maintenance, there is a "gray" area where we apply common sense and reason.

When you have gained an understanding of the fundamental theories of operation of the systems and equipments you work with and operate, you will be well prepared to present an educated opinion as to the cause of a problem, potential or real. To do this, a senior radioman with many years of experience is not necessary. From an operational standpoint, any RMSN or RM3 should be able to capably handle the procedures applicable to proper monitoring and basic remedial action, when necessary. Armed with this knowledge of the equipment you operate and the systems over which you have control, you can functionally test and diagnose in an orderly and professional fashion. This orderly manner of approach is further enhanced by logic and common sense.

In any situation involving diagnosis, the first step is recognizing trouble symptoms. All communications equipments are designed to do a specific job or group of jobs according to the requirements established by the Navy and the equipment manufacturer. This demands that a certain type of performance be obtainable at all times. Quality assurance in the form of preventive maintenance is performed in order to maintain the various communications equipments at peak or near peak operating condition. However, when PMs and other QA acts do not accomplish this, the first, most important step is symptom recognition.

Since a trouble symptom is a result of some undesirable change in equipment performance, we must have some standard of normal performance to serve as a guide. By comparing the present performance with the normal, you can recognize that a trouble symptom exists and make a decision as to just what the symptom is. For example, the normal sound from a superheterodyne receiver is a clearly understandable reproduction of the transmitted voice. Barring atmospheric interference, if the transmission is received garbled and unable to be understood, the operator knows that a problem exists somewhere between the antenna and the receiver output.

Evaluation of Equipment Performance

During the process of doing their assigned job, most communications equipments yield information which an operator can either see or hear. Electrical information to be presented as sound must be applied to a loudspeaker or a headset. For a visual display, the information must be applied to an oscilloscope or meter. Normally, these displays are built into the equipment. For example, the plate current meters on the front panel of transmitters monitor the RF amplifier stage. During tuning and operation, this meter (or meters) has a certain amount of monitored current that is considered excessive, too low, or within operating limits. By knowing the normal display, you could detect a potential problem by recognizing a variation from the normal.

Even if the audible or visual information is present, the equipment may not be performing normally. Whenever the equipment is doing its job but is presenting the operator with information that does not correspond with the desired specifications, the performance is said to be "degraded". Such performance must be corrected just as quickly as an equipment failure. Therefore, it is imperative that all operators have a thorough knowledge of all front panel adjustments and indications concerning their equipment.

Use of Operating Controls

Operating controls are the controls which the equipment operator must operate in order to supply power, tune, adjust, select, etc. By their very nature, operating controls must produce some sort of change in equipment conditions. These changes indirectly affect other circuits and components inside the equipment chassis. The information displays will enable you to "see" the changes which take place when the controls are manipulated. Control manipulation can cause detrimental effects as well as desirable ones. By manipulating them in an improper manner, you can create a problem in the equipment over a period of time. Also, unless you observe the proper precautions and operating habits when attempting to diagnose a trouble symptom, even more damage can result. Meters placed on the front panels of communications equipment serve as an aid in determining voltage and current values at crucial points in the equipment circuitry. Operating controls should never be adjusted so that these meters exceed their maximum ratings.

Incorrect operating control settings will produce an apparent trouble symptom. The equipment may be operating perfectly, but because of incorrect settings, the information displays will not correspond to the expected performance. Operators of communications equipments must have a thorough knowledge of all front panel operating controls for this reason.

Often, there are certain other precautions associated with specific types of equipments. This is very often true of communications equipments. For example, many CRTs have a brightness control, sometimes called an "intensity" control. This control should not be adjusted to produce an excessively bright spot on the screen of the CRT. Repeatedly doing so will decrease the life of the tube. Many receivers and converter/comparator groups have CRT displays. When they are used often, you will notice a "burned" spot on the face of the screen that takes the shape of the signal usually routed through that particular group. Normally, this shape will be in the form of a frequency-shift keyed teletype signal.

Another precaution concerns the adjustment of range selector switches on any type of indicating meter. Improper range selection during preventive maintenance procedures and during operations often results in either improper readings or meter damage. A knowledge of the circuit changes that take place when you adjust a control will enable you to think ahead of each step you take in diagnoses and to anticipate any damage which might result. Remember, you can save a lot of unnecessary time by exercising care when you are at the controls.

Recording Data

Proper diagnosis cannot be fully accomplished unless the observed indications can be completely evaluated. This means, the indications are evaluated in relation to one another as well as in relation to the overall operation of the equipment. The easiest method for accomplishing this is to have all data handy for reference by recording the information as it is obtained. This will enable you to properly diagnose with all information at hand. It will also enable you to check the equipment or group technical manual and compare the information with detailed descriptions if this is necessary. By recording all control positions and the associated meter and indicator information, you can quickly reproduce the information and check to see if that is correct as well as put the equipment in exactly the operating condition that you wish to test. Whenever the adjustment of a control has no effect upon the symptom, this fact should also be recorded. The information may later prove to be just as important as information that directly changes the operating status of the equipment.

Use of Functional Block Diagrams

Communications equipments and groups are subdivided into functional units. Each unit accomplishes a specific function. The units are interconnected so that the individual functions will be performed in the proper sequence to accomplish the overall operational function of the set. There is no indication in the block diagram as to how each function is accomplished, but to an operator, this is not important. By knowing the functions of the various units making up the equipment or system, trouble symptoms can very often be localized without having to utilize the aid of a technician.

CHAPTER 9

COMMUNICATIONS ORGANIZATION

Naval communications must always be ready to shift to the requirements of wartime. Our peacetime organization and training must be capable of making this shift with a minimum of changes. Without this proper transition, our fleet would be essentially helpless and vital information necessary to defense would never reach its destination. It is for this reason that we have a well-defined communications structure, with responsibilities assigned to each element, from the Chief of Naval Operations (CNO) down to the individual units of the fleet.

In order to present a more cohesive effort in the event of war, the National Communications System (NCS) was established. The NCS provides a unified governmental system which links together the communication facilities and components of the various federal agencies. Essentially, it would be correct to say that the efforts of all branches of the federal government, both civilian and military, are part of the overall NCS, even though each department and branch has its individual organization, methods, and procedures.

THE NAVAL TELECOMMUNICATIONS SYSTEM

The word "telecommunication" is defined as "all types of systems in which electric or electromagnetic signals are used to transmit information between or among points". The Naval Telecommunications System (NTS) is comprised of all the terminal, transmission, switching, cryptographic, and control devices used for the transmission of operational information in the Navy. The NTS provides electrical and optical communications from the Commander in Chief and naval commanders to and down through all naval forces under their command. It should be pointed out that the NTS is used primarily for the exercise of command and control over the naval operating forces, not necessarily the shore establishment. Most of the shore establishment is served through the Defense Communications System (DCS). Naturally, there is an overlapping portion of each system, each including the other where necessary. The overall mission of the naval telecommunications system is to provide and maintain reliable, secure, and rapid telecommunications based on war requirements to meet the needs of naval command, facilitate naval administration, and satisfy the Joint Chiefs of Staff approved requirements of those DCS facilities as assigned.

Operational direction and management control of the assigned elements of the NTS is the responsibility of the Commander, Naval Telecommunication-Command Headquarters (COMNAVTELCOM). In Naval Communication COMNAVTELCOM determines the responsibilities of each of the various commanders, whether they are fleet commanders or commanding officers of ships. For example, direction and control of all naval broadcasts, ship-shore, and other direct fleet support telecommunications is assigned to the Fleet Commanders in Chief. That is to say that all Pacific Fleet naval broadcasts are under the operational direction and control of Commander in Chief, Pacific Fleet (CINCPACFLT). The same applies to Atlantic Fleet naval broadcasts; they are under the operational direction and control of the Commander in Chief, Atlantic Fleet, (CINCLANTFLT). The fleet commanders in chief are then responsible for the adequacy of communications in order to satisfy the needs of their respective fleets. They, in turn, will assign broad communications responsibilities in the form of their fleet operational orders (OPORDERS) that will be complied with at every level down to and through individual commanding officers of operating ships. The commanding officers of all affected commands will utilize only those portions of the fleet commander's OPORDER that affect them, with regard to communications. In this very simple yet direct manner, the NTS is administered at every operational level in the fleet, according to that ship's mission and communications need.

The Naval Telecommunications Command is composed of the following elements:

(1) Naval Telecommunications Command Headquarters and Staff (COMNAVTELCOM).
(2) Naval Communications Stations (NAVCOMMSTAs).
(3) Naval Communication Units (NAVCOMMUs).
(4) Naval Radio Stations (NAVRADSTAs).
(5) Naval Communications Technical Groups (NAVCOMMTECHGRUs).

Naval Communication Stations (NAVCOMMSTAs)

A NAVCOMMSTA is a communications station with a primary responsibility for communications in a large, specific area. It includes all communications facilities and equipment required to provide essential fleet support and fixed communication services. For example, NAVCOMMSTA, Diego Garcia serves a large geographical area of the Atlantic as well as a large area of the eastern United States. It also includes facilities and equipments necessary to interface with all other NAVCOMMSTAs or communication units on all naval communications matters. Another example would be NAVCOMMSTA, Stockton, CA.

Naval Communication Unit (NAVCOMMU)

A NAVCOMMU is a telecommunications facility that is assigned a limited, or specialized mission. A NAVCOMMU is much smaller than a NAVCOMMSTA in terms of personnel and facilities and is identified according to its geographical location: for example, NAVCOMMU, CHRISTCHURCH, New Zealand.

Naval Radio Station (NAVRADSTA)

A NAVRADSTA is a component of a NAVCOMMSTA, even though it may be physically located some distance from the NAVCOMMSTA. A NAVRADSTA is classified as either a transmitting or a receiving station, depending upon the function it performs. Therefore, NAVRADSTAs are either suffixed by the letter "T" or "R", designating "transmit" or "receive". For example, NAVRADSTA (T) Jim Creek, Washington is a component of NAVCOMMSTA, Stockton, CA but is physically located a considerable distance from it.

Naval Communications Technical Groups (NAVCOMMTECHGRUs)

A NAVCOMMTECHGRU is not a part of a NAVCOMMSTA or the basic communications structure. Technical groups are usually created on a "need" basis and are in support of a particular mission or function. For example, NAVCOMMTECHGRU, Rio De Janiero was formed to support the missions of the American embassy there as well as other functions important to the national and naval interest.

DEFENSE COMMUNICATIONS SYSTEM (DCS)

The Defense Communications System (DCS)—exists to support the three military departments (Navy, Army, Air Force) and other Department of Defense activities. The circuits that make up the DCS are government-owned or leased and are point-to-point circuits that are long-haul and world-wide. It combines into a single communications system many of the elements of the three military forces. The Navy DCS facilities are all ashore with the exception of the National Emergency Command Posts Afloat (NECPA) facilities.

Although the NTS and the DCS are two different communication systems (fleet and ashore, respectively), they are constantly intermixed. For example, as often happens a naval message originated aboard ship and destined for a shore activity will leave the ship over the NTS, but final routing is accomplished over the DCS circuits of the Navy. NAVCOMMSTAs and NAVCOMMUs are the points where message traffic is transferred between NTS and DCS circuits. The interface between the NTS and DCS is always provided by the shore communication facility.

Defense Communications Agency (DCA)

Operational direction over the DCS is accomplished with the Defense Communications Agency (DCA). With reference to the DCS, the DCA must ensure that the system is operated and improved so as to meet the continuing long-haul, point-to-point requirements that become necessary.

The DCA functions under the management of a director who is appointed by the Secretary of Defense. The Director, DCA is a general or flag rank officer and has the responsibility of coordinating the combined communications elements of the three military forces.

THE DCA CONTROL COMPLEX

The DCA operates a communications control complex that consists of a number of operational control centers. The focal point for all of the operational control centers is the DCA Operations Center (DCAOC) located in Washington, D.C. (See figure 9-1.) The operations center maintains and displays the status of the world-wide DCS. Figure 9-1 provides a pictorial view of the world-wide DCAOC complex.

Information is presented on display panels covering all data required to intelligently analyze and control the world-wide system. When displays indicate a need for operational instructions to correct problems, the operations center supervisor issues them by telephone or teletypewriter to the appropriate activity. The center's control area contains a series of operator consoles with computer access. Through these consoles, the supervisor can obtain and display detailed information to assist in systems diagnosis and decision making.

Area Communications Operations Centers (ACOCs)

In addition to the central operations center, there are two area centers called Area Communications Operations Centers. These area centers are subordinate to the operations center and report to it. Their purpose is to exercise operational direction over the DCS components in their geographical areas. They accomplish this in much the same manner that the operations center controls the entire world.

Regional Communications Operations Centers (RCOCs)

Subordinate to the area centers are the regional centers, called Regional Communications Operations Centers. These centers take care of the DCS within their own region according to their own needs, and makes status reports to the appropriate area center. Each DCS station in any of the three military branches is under the circuit direction of a designated ACOC or RCOC.

NAVAL COMMUNICATION AREAS

Naval communications is organized so that fleet and force commanders will have optimum communications no matter where they operate. This is partially accomplished through the division of the world into communication areas.

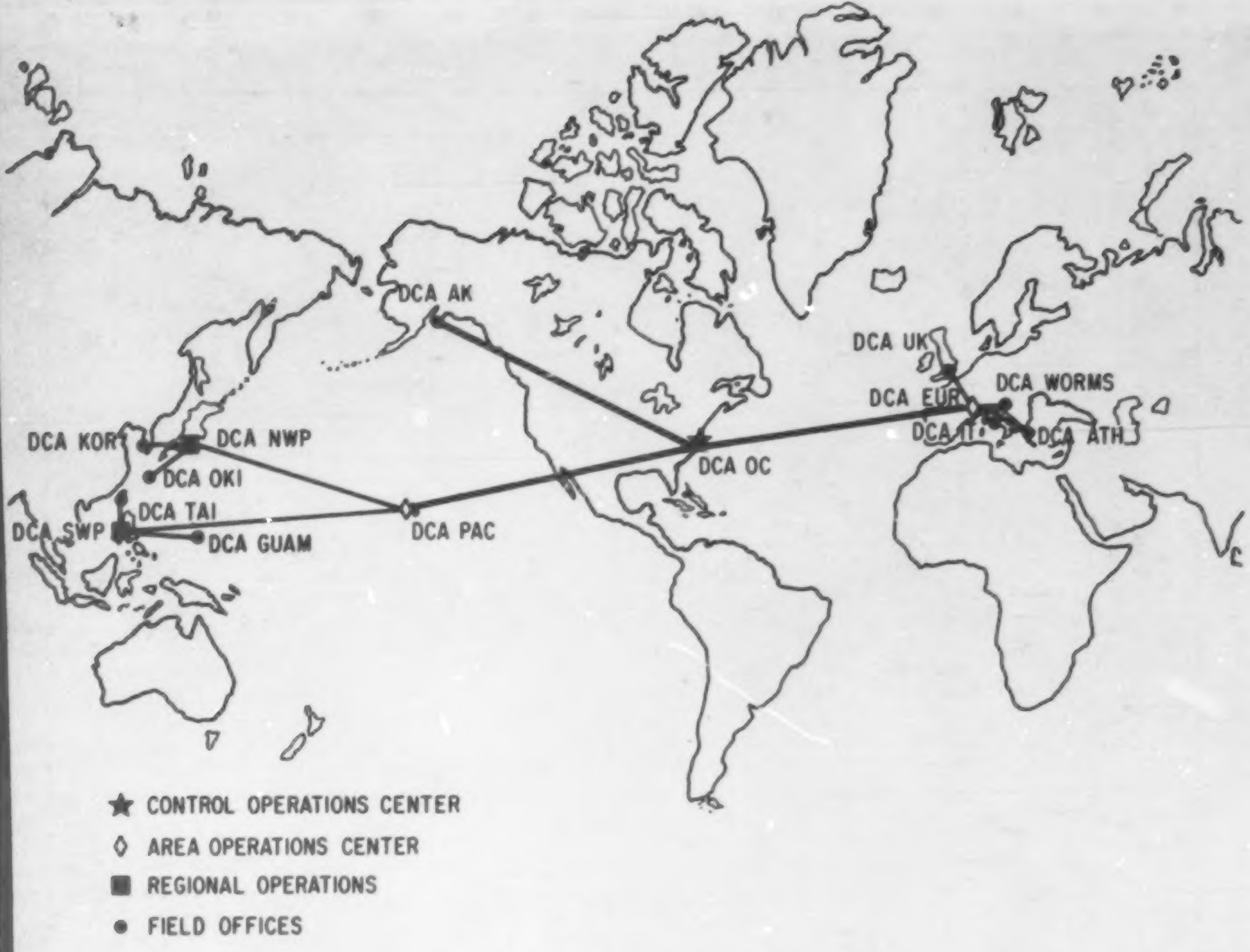
The world is divided into four Naval Communication Areas (NAVCOMMAREAS): EASTPAC, WESTPAC, ATLANTIC and MED. (See figure 9-2.) All communications activities within any of these geographical areas are organized to operate under the direction of a master station. The master station exercises coordination and control of all naval communication system fleet broadcasts, ship-to-shore, air-ground, and other tactical circuits within the NAVCOMMAREA. The master station is known as the Naval Communication Area Master Station (NAVCAMS). There are other NAVCOMMSTAs or NAVCOMMUs within the NAVCOMMAREA that are called alternate NAVCAMS. They coordinate control of communications under the direction of the NAVCAMS.

SHORE COMMUNICATIONS DEPARTMENTS

A NAVCOMMSTA or NAVCOMMU may be comprised of several functional components, depending upon need. Basic organization and functional duties may vary depending upon the station unit mission, but there are general duties common to the components of each. These duties deal with the Naval Telecommunications Center/Message Center, Fleet Center, Technical Control Facility, Receiver Site, Transmitter Site.

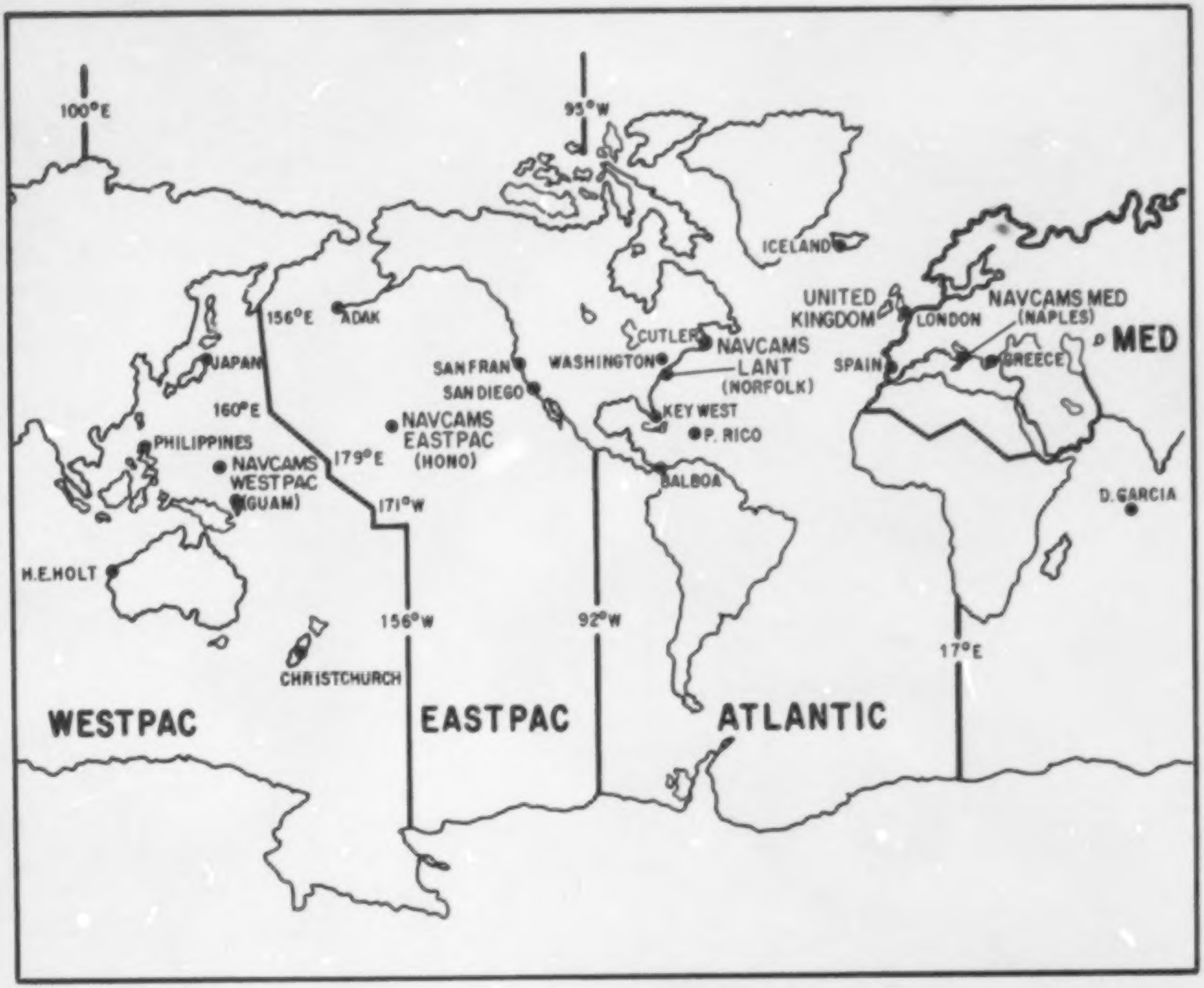
Naval Telecommunications Center/Message Center

A Naval Telecommunications Center or Message Center is a separate organizational entity which provides rapid communications services to several naval commands and activities. Referred to as an NTCC, it is established to provide a message service where a need exists


DCA AK
DCA UK
DCA WORMS
DCA EUR
DCA IT
DCA ATH
DCA OC
DCA KOR
DCA NWP
DCA OKI
DCA TAI
DCA SWP
DCA GUAM
DCA PAC
CONTROL OPERATIONS CENTER
AREA OPERATIONS CENTER
REGIONAL OPERATIONS
FIELD OFFICES

31.60

Figure 9-1.— DCA Control Complex


100°E
95°W
ICELAND
UNITED KINGDOM
LONDON
NAVCAMS MED (NAPLES)
MED
SPAIN
GREECE
156°E
ADAK
CUTLER
NAVCAMS LANT (NORFOLK)
WASHINGTON
SAN FRAN
SAN DIEGO
JAPAN
160°E
NAVCAMS EASTPAC (HONO)
KEY WEST
P. RICO
PHILIPPINES
NAVCAMS WESTPAC (GUAM)
179°E
171°W
BALBOA
D. GARCIA
H.E.HOLT
156°W
92°W
17°E
CHRISTCHURCH
WESTPAC
EASTPAC
ATLANTIC

76.132

Figure 9-2.— The four naval communication areas (NAVCOMMAREAs)

due to a large volume of message traffic. An NTCC is not a physical part of a NAVCOMMSTA or NAVCOMMU, but does relieve them of message responsibilities to certain commands in high traffic volume areas.

NTCCs also relieve afloat communications personnel of many watchstanding requirements by assuming a ship's message traffic guard whenever they are berthed in their area. This part of the NTCC's service is called the Shore Based Message Service System (SBMSS) and is utilized in areas of high need, for example, where a large number of ships are berthed. The duties and responsibilities of NTCCs are listed in NTP 4.

Fleet Center

The fleet center is that organizational entity which provides an interface between shore and afloat communication systems. Typical systems and circuitry associated with Fleet Center operations include NAVCOMPARS, Fleet Broadcasts, Full Period Ship-Shore Termination, Primary and Secondary Ship-Shore, Fleet Flash Nets, Air-Ground Circuits, Electronic Courier Circuits, and those circuits required for coordination purposes. The fleet center also operates maritime and aeronautical distress and public service circuits.

Technical Control Facility

Technical Control is the focal point of the communications department ashore. From here, all inter-patching between the various divisions is accomplished. Technical control is also the central monitoring point for all transmit and receive circuits. The transmitters located at the transmitter site are keyed from this facility and all corrective actions dealing with systems diagnosis or quality control are initiated here. Basically, the technical control facility can be thought of as the master switchboard and monitoring station for the entire communications department.

Cryptographic Center

The crypto center provides all off-line crypto service and assigns appropriate routing of encrypted traffic within the command. The crypto center also provides message processing and accountability for TOP SECRET message traffic.

Navy Commercial Refile Facility

The Navy Commercial Refile Facility provides interface between U.S. Government telecommunications systems and commercial systems (domestic, foreign, or international). It is here that all necessary commercial communications billing, reporting, and filing take place.

Receiver Site

The receiver site is equipped with the necessary facilities and equipment to receive radio frequency energy and convert it into signals that are routed to the Technical Control Facility for further processing. The basic work-related functions include receiver tuning, DC/Audio patch manipulation, quality monitoring of received signals, and antenna control.

Transmitter Site

The transmitter site is equipped with the necessary facilities and equipment to radiate radio frequency energy. The information to be transmitted is received from the Technical Control Facility in the form of analog or digital data. The basic functions of the transmitter site include transmitter tuning, DC/Audio patch panel manipulation, quality monitoring of transmitted signals, and antenna switching.

SHIPBOARD COMMUNICATION ORGANIZATION

Not all ships have a communication department. NWP 4 designates the types of ships in which there is a Communication Department. In ships that are not so designated, communications personnel are assigned to the Operations Department. Regardless, the communications functions are the same. The shipboard communications organization is structured so that all assigned tasks and functions are carried out and fulfilled. Senior enlisted personnel may be assigned the duties normally assigned to officers whenever sufficient numbers of officers are not available to fulfill assigned billets.

Commanding Officer

At all times and under all circumstances, the ship's commanding officer is responsible for the communications of his ship. The only exception to this is whenever a flag is embarked on-board and the communications functions of the ship have been assumed by the flag. However, even then, the commanding officer must assume responsibility for proper internal handling of message traffic within the ship.

Communication Officer

The ship's communication officer is responsible for the organization, supervision, and coordination of the ship's exterior communications. Additionally, the communication officer is responsible for the management of related internal systems. The communication officer must be cognizant of all communications annexes to Operation Plans affecting the mission of the ship in order to advise the commanding officer on such matters.

Radio Officer

The radio officer is in charge of the communications center. He is responsible for organizing and supervising his personnel to ensure accurate, secure, and rapid communications. Being responsible to the ship's communications officer, the radio officer prepares the ship's communication plan which includes proper allocation of equipment for operations; preparing and maintaining the communication watch, quarter, and station bill; conducting the communications training program; and preparing Standard Operating Procedures (SOPs) for the communications center. On small ships, the communication officer and the radio officer may be one and the same.

CMS Custodian

The Communication Security Material Custodian (CMS) is responsible to the commanding officer for managing the command's CMS account in accordance with the instructions contained in CMS-4. It is his responsibility to advise the commanding officer on the status of the account at all times on matters concerning physical security and handling of CMS publications. Stowage of CMS publications as well as drawing, correcting, and destroying them are also the responsibility of the CMS Custodian. He is also responsible for the submission of all reports concerning the accounting for and the issuing of any CMS publications.

SHIPBOARD OPERATIONAL ORGANIZATION

The function of a ship's operational organization consists of message processing, circuit operation, technical control, data processing and operation, control of voice circuits, and operation of satellite circuits where installed. Needless to say, the combined efforts of the operational organization is performed in various spaces on the ship simultaneously. The following is a discussion of the duties and responsibilities of some of the key billets within this organization.

Communication Watch Officer (CWO)

The CWO is responsible to the communications officer for ensuring that the ship's communication capabilities are exploited to the fullest in accordance with the mission of the ship. He is responsible for all incoming and outgoing traffic within the ship's communication organization. He ensures that all messages, transmitted or received, are handled rapidly and accurately in accordance with existing regulations. The CWO ensures compliance with existing communications directives and monitors the performance of the on-watch personnel and spaces. For a detailed listing of all of the duties of the CWO, consult NTP 4.

Senior Watch Supervisor (SWS)

When assigned, the SWS is the senior enlisted man on watch in communication spaces. He is responsible to the CWO for all communications. The SWS notifies the CWO on all matters in his area of responsibility of an urgent or unusual nature. The SWS examines operational logs and monitors equipment alignment and operation as well as directing necessary action to prevent or overcome message backlogs. In addition to the required duties listed in NTP 4, the SWS is also responsible for any other duties assigned by the CWO.

Main Communication Supervisor

The main communication supervisor is responsible to the CWO and SWS for supervising message processing and circuit operation. He directly supervises all Radiomen on watch in the message processing center. He is also responsible for notifying the CWO and SWS on all matters in their area of responsibility of an unusual or urgent nature.

Technical Control Supervisor

The technical control supervisor ensures that quality monitoring and control procedures are employed on all systems in use. He also maintains the status board showing pertinent information relevant to all equipment, nets, and circuits in use. The "tech-control" supervisor directly supervises all personnel assigned to technical control and transmitter room spaces.

COMMAND SHIP COMMUNICATIONS

The term "Flagship Communications" could be inserted for "Commandship Communications" and would mean the same thing. Either term, as used, means that a group, squadron, or division commander is embarked onboard, thereby making that vessel the "flagship"; or "commandship". In flagships, the embarked commander assumes jurisdiction over communications functions. The flag communications officer is then responsible for the ship and flag communications requirements. However, the internal routing of message traffic remains the responsibility of the ship on which the flag is embarked.

When a flag is embarked, the ship's communication officer, communications watch officers, and enlisted communications personnel may be ordered by the flag to additional duty in the flag communications division. These personnel shall be directly responsible to the flag communications officer for the operation of the flag communication functions. The ship's communication officer reports to the flag communication officer and is the contact officer for matters pertaining to the handling of ship and staff message traffic.

OPERATION ORDERS (OpOrders)

Operation Orders (OpOrders) are directives that are issued by naval commanders to subordinates for the purpose of effecting coordinated execution of an operation. Operation orders are prepared in accordance with a standard format, as set forth in NWP 11, Naval Operational Planning.

An operation order consists of a basic plan made up of the heading, body, and ending. The basic plan, contained in the body of the operation order, is kept very concise and lacks detail. The more detailed information pertaining to the various departments aboard ship are contained in the added enclosures, called annexes and appendixes. The annex of most concern to Radiomen is the Communications Annex. The communications annex, along with its associated appendixes and tabs, elaborate on the many details to be considered in the planning of communications for any particular operation. It is in this annex that Radiomen find all of the applicable circuits, equipment, frequencies, etc., that will directly concern them.

To provide uniformity, each communication annex of an operation order for U.S. Navy operations is prefaced by a standard paragraph which reads: "Communications in accordance with effective edition of NWP 4 and appropriate Joint, Allied, and Navy Department publications". In the event that an OpOrder does not include a communication annex, a Communication Operation Plan (ComOpPlan) is promulgated separately.

COMMUNICATIONS MATERIEL SUPPORT

In order to maintain communication facilities and equipment in peak operating condition, proper materiel support is indispensable. Without it, the mission of the communications complex, and thereby the naval mission, would be severely impaired.

Preventive Maintenance

Preventive maintenance is a program of systematic inspection to determine the condition of equipment and to detect substandard performance. The Standard Navy Maintenance and Material Management (3-M) System is a program designed to aid in attaining and maintaining optimum fleet readiness through effective use of available resources. The 3-M system is comprised of two areas:

1. The Planned Maintenance System (PMS)
2. The Maintenance Data Collection System (MDCS)

196

The Planned Maintenance System (PMS)

PMS deals with planning, scheduling, and resource management in order to provide uninterrupted equipment performance within its design characteristics. The PMS system provides each department with the means to plan, schedule, and control maintenance in accordance with routine schedules. PMS pertains to preventive maintenance rather than corrective maintenance. The basic tools of the PMS system are:

1. The Cycle Schedule
2. The Quarterly Schedule
3. The Weekly Schedule
4. Maintenance Requirement Cards (MRCs)

The Cycle Schedule is a visual display of preventive maintenance requirements based on the ship's entire overhaul cycle. It is from this overall schedule of preventive maintenance that the Quarterly Schedule is made.

The Quarterly Schedule (sometimes referred to as the "long-range" schedule) is a visual display of preventive maintenance to be accomplished during the current and up-coming quarters. The Cycle and two Quarterly Schedules are contained in a holder called the "Maintenance Control Board" and is kept up to date by the communications division department head.

The Weekly Schedule is a visual display of the preventive maintenance to be accomplished during the current week. It assigns specific preventive maintenance tasks to specific personnel to be accomplished on a specified date. The communications division leading petty officer assigns the work and records its completion on the weekly schedule.

Maintenance Requirement Cards (MRCs) define the preventive maintenance to be accomplished in sufficient detail to enable personnel to perform the tasks without difficulty. Listed on MRCs are the enlisted rate, time, tools, parts, and materials required to perform the preventive maintenance task. Applicable safety precautions are also contained on the MRCs. When assigned a particular maintenance task, the person involved simply takes the applicable MRC and performs the task according to the directions contained on it.

THE MAINTENANCE DATA COLLECTION SYSTEM (MDCS)

MDCS provides a system of documenting man hours expended, material expended, and equipment downtime. The MDCS is utilized only when corrective maintenance is performed. Shipboard Maintenance Action, Work Request, and Deferred Action forms are used to document all necessary information when MDCS is used. The Shipboard Maintenance Action form is a document used to record PMS and other preventive maintenance actions, with the exception of daily and weekly PMs. The Work Request is a document used to request outside assistance when corrective maintenance is beyond the capabilities of ship's force personnel. The Deferred Action is used to report corrective maintenance actions that are deferred due to ship's operations, lack of repair parts, or a requirement for outside assistance.

All material expended on maintenance, and the cost of such materials, must be documented and reported in the MDCS. One of the two forms used to document the expenditure of materials is NAVSUP 1250, a five part document used to obtain repair parts. NAVSUP 1250 is used by ships not having automated supply records. NAVSUP 1348 is the document used to obtain repair parts on ships having automated supply records. The MDCS is further detailed in the Maintenance and Material Management (3-M) Manual (OPNAV 4790.4).

REPAIR PART SUPPORT

Prompt, efficient repair of inoperative or malfunctioning equipment is dependent upon adequate repair parts support. Each command has an allowance of spare parts on-board as recommended by the Consolidated Shipboard Allowance List (COSAL) or, in the case of shore activities, the Electronic Repair Parts Allowance List (ERPAL). These allowance lists are adjusted to a prescribed range and depth of stocked parts based on the usage rate of the equipment. The usage rates are obtained by correct reporting of failures as prescribed by the 3-M System. As new part stock level requirements are determined, the command allowance list will be updated. Spare part support for ships in overhaul is provided by the Supply Overhaul Assistance Program (SOAP).

Logistic support for the communication complex includes the effort to ensure that consumable supplies are available when required. Consumable supplies are those items such as paper, pencils, log and record forms, teletype ribbons, and cleaning supplies that are used in daily operation. An adequate supply must be maintained to prevent interruption of communication center operation.

The supply department records stock levels for all items maintained in the command's supply system. These stock levels are based on the rate at which the material is used and indicate a 90 day supply. When the items drop to two-thirds of the 90 day level, they will be reordered in sufficient quantity to raise the supply back to the 90 day level.

Establishing Stock Levels

The communication organization must determine its own stock level requirements for materiel and provide this information to the supply department. This information is then included in the overall requirements for the command. Accurate past usage is the best guide for establishing these levels. However, it is equally important that the requirements for future operations be reviewed to determine if changes to these levels are indicated. For example, the stock levels for a ship scheduled for overhaul may require reduction, whereas the levels generally require an increase if a ship's operation is scheduled. Stock levels must be reviewed at regular intervals to ensure that adequate supplies are on hand when required and, at the same time, to ensure that a surplus does not accumulate. Excessive amounts of supplies for day-to-day use must not be kept in communication spaces. The supply department should be promptly notified when changes to the basic logistic support requirements are necessary as this ensures that adequate levels are maintained for changes in equipment utilization or to comply with new procedures.

NAVAL WARFARE PUBLICATIONS LIBRARY (NWPL)

The "NWPL" is the label assigned to that group of communications and tactical publications that are designated as part of the command's publication allowance. These publications contain required procedures, signals, and other information of an operational or mission essential nature and may involve safety. The Naval Warfare Publications Library (NWPL) provides for the central administration and maintenance of these publications. These publications are promulgated by CNO and include:

1. Naval Warfare Publications (NWP Series)
2. Naval Warfare Information Publications (NWIP Series)
3. Fleet Exercise Publications (FXP Series)
4. Allied Tactical Publications (ATP Series)
5. Allied Exercise Publications (AXP Series)
6. USN Addenda to Allied Publications
7. Miscellaneous Allied Publications (AAP, AEP, AHP, ALP, AMP, and APP Series)

The objective of central administration of naval warfare publications is to assure that these publications are correct and readily available for their intended use. This necessitates a basic library file out system and signature custody as required for classified material. Some naval warfare publications contain information which is necessary for the proper performance of individual duties and important for individual professional development. Therefore, naval warfare publications must be readily available for use by individuals with a duty related need or a general professional need for the information.

Naval Warfare Publications Custodian (NWPC)

Responsibility for the management of the NWPL is assigned to an officer or senior petty officer. This assignment is a collateral duty and the person so assigned is known as the Naval Warfare Publications Custodian. He is responsible for the overall administration and security of the NWPL.

The NWPL "Clerk" is a person assigned by the NWPC. The clerk is responsible for the upkeep and maintenance of the library. He maintains all records and receipts in central file, orders all necessary publications and changes, and enters all necessary changes and amendments to the publications in the NWPL. The clerk reports all matters of concern to the Library Custodian.

NWPL Administration

As a library, the NWPL issues publications to holders and short term users. A holder is a person who has a permanent subcustody of a publication under the central control of the NWPL. The holder is responsible for maintaining the publication, entering all necessary changes and amendments, and providing adequate security. A user is a person who checks out a publication for temporary or short term custody.

Signature custody and disclosure records for classified material is maintained as required by OPNAVINST 5510.1. Signature custody of unclassified publications is not required; however, the records of the NWPL should provide an up-to-date location of publications which have been issued to holders or checked out to users. Where signature custody is not required, a locator card may be used in place of a catalog card to check out publications to users.

Maintenance of the NWPL

In maintaining the NWPL, several basic files are used. One is the Custody File. The custody file contains a catalog card (shown in figure 9-3) for each naval warfare publication on allowance or on board. The purpose of this file is to maintain an up-to-date record of the holder and location of each publication in order to facilitate the entry of timely and proper changes to the publication. The catalog card can also be used as a custody card and a destruction record. When used as a record for security purposes, it shall be retained as required by OPNAVINST 5510.1.

The Administrative File contains copies of all correspondence, in chronological order, pertaining to naval warfare publications. Included in the administrative file is the Change Entry Certification form (shown in figure 9-4). This form is filled out by the holder of the applicable publication. The administrative file is sometimes called the "Transaction File". The retention period for material in this file is two years.

The Publication Notice is a printed notice, giving a brief summary of a new publication or change. It is included with each hardback copy and is furnished solely for routing by the NWPC and shall be destroyed when no longer useful. These notices keep all cognizant personnel informed of the changes to naval warfare publications.

Procurement of Tactical Warfare Publications

Tactical warfare publications are stocked in the Cognizance Symbol "I" stock points. Reactivated and newly commissioned activities and ships are automatically furnished an initial supply of publications in the quantity stipulated for such commands in the Requirements List of Naval Warfare Publications for the Operating Forces or the Naval Shore Activities. When referring to NWPL publications, "long" or "short" titles are used. A long title is a descriptive word or phrase that identifies the subject matter of a document or the type of device it is, for example, "Basic Operational Communications Doctrine". A short title is a brief, identifying combination of words, letters, or numbers applied to specific items of material. For example: NWP 4.

NWPL Binders

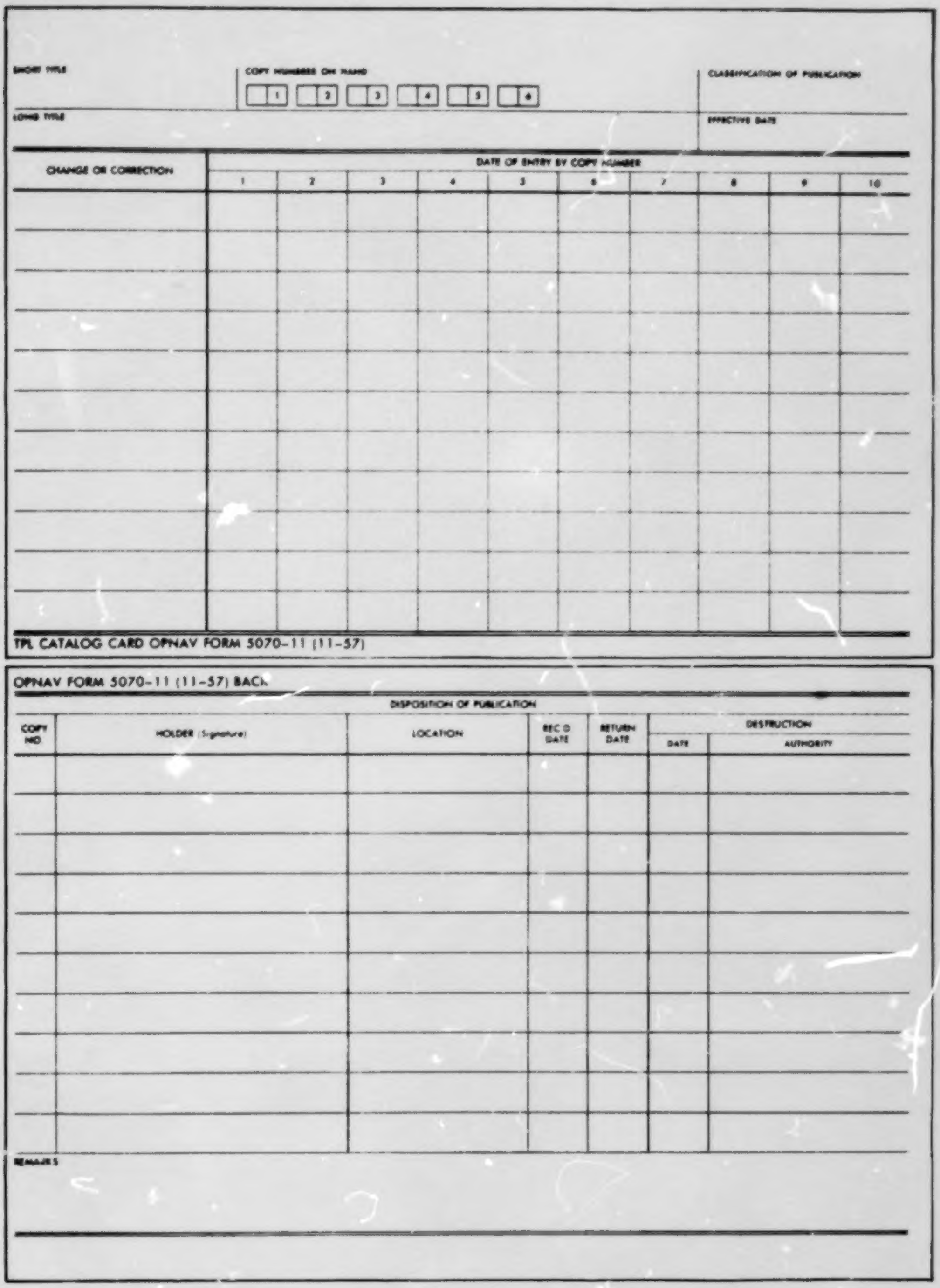
Binders for U.S. tactical warfare publications have been color coded according to security classification. This color code is:

Secret—RED
Confidential—YELLOW
Unclassified—BLUE

All NATO publications have or will have a white binder regardless of security classification.

Entry of Changes

The timely and accurate entry of changes to NWPL publications is necessary to ensure accurate, up-to-date information as well as information continuity. Changes to NWPL publications are the responsibility of the clerk. However, often changes are so numerous that all communication personnel become involved. It is the responsibility of the NWPL clerk to ensure that all personnel making changes to NWPL publications are informed as to the proper manner of doing so. Among the things that the



SHORT TITLE

COPY NUMBERS ON HAND

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

CLASSIFICATION OF PUBLICATION

LONG TITLE

EFFECTIVE DATE

CHANGE OR CORRECTION	DATE OF ENTRY BY COPY NUMBER									
	1	2	3	4	5	6	7	8	9	10

TPL CATALOG CARD OPNAV FORM 5070-11 (11-57)

OPNAV FORM 5070-11 (11-57) BACK

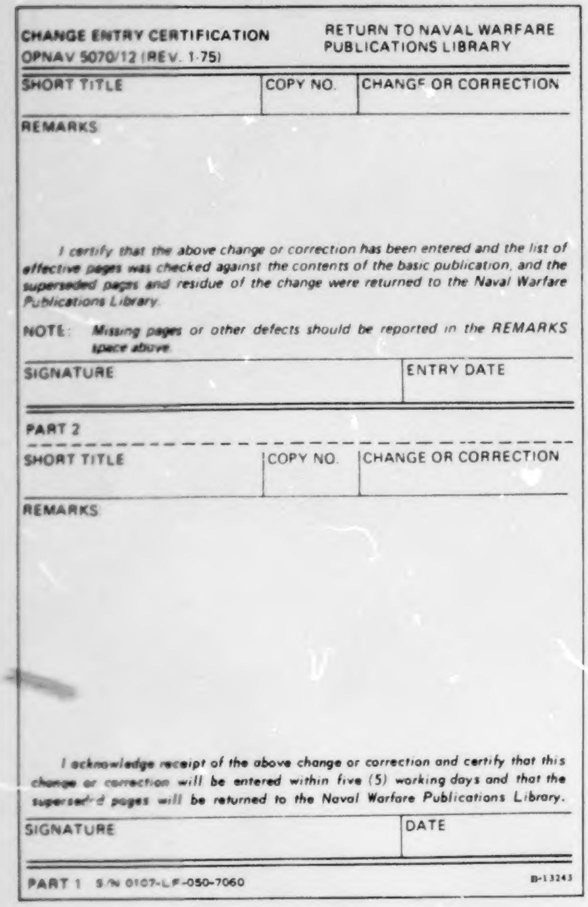
DISPOSITION OF PUBLICATION

COPY NO	HOLDER (Signature)	LOCATION	REC'D DATE	RETURN DATE	DESTRUCTION	
					DATE	AUTHORITY

REMARKS

76.133

Figure 9-3.— CUSTODY FILE Catalog Card



CHANGE ENTRY CERTIFICATION
OPNAV 5070/12 (REV. 1-75)

RETURN TO NAVAL WARFARE PUBLICATIONS LIBRARY

SHORT TITLE | COPY NO. | CHANGE OR CORRECTION

REMARKS

I certify that the above change or correction has been entered and the list of effective pages was checked against the contents of the basic publication, and the superseded pages and residue of the change were returned to the Naval Warfare Publications Library.

NOTE: *Missing pages or other defects should be reported in the REMARKS space above.*

SIGNATURE | ENTRY DATE

PART 2

SHORT TITLE | COPY NO. | CHANGE OR CORRECTION

REMARKS

I acknowledge receipt of the above change or correction and certify that this change or correction will be entered within five (5) working days and that the superseded pages will be returned to the Naval Warfare Publications Library.

SIGNATURE | DATE

PART 1 S/N 0107-LF-050-7060 B-13243

76.134

Figure 9-4.— Change Entry Certification Form

clerk and all holders must be aware of when changes are entered are:

1. Check the change Foreword or Letter of Promulgation for the effective date of the change and ensure that the publication to be corrected is effective.

2. Completely read the specific instructions contained in the change or correction before beginning the entry.

3. Use any dark ink, EXCEPT RED, for pen-and-ink entries. Red is not visible under red night lights used at sea.

4. Lengthy pen-and-ink corrections should be typed in on a pasted-in cutout. (All superseded matter should be deleted in ink prior to inserting the cutout).

5. Use flaps when no room exists for a cutout. (When used, flaps should be attached to the binder side of the page.)

6. For pasting, use rubber cement or mucilage in lieu of glue or gummed tape.

7. After pen-and-ink corrections, a notation should be made in the margin adjacent to the entry, citing the source of the correction, e.g., "Alcom 7-76".

Upon completion of entry of page changes, a page check should be conducted and recorded in the "Record of Changes and Corrections".

Corrections to NWPL publications are promulgated by message when the material requires rapid dissemination. These numerical message corrections (NMCs) are normally sent as basegrams. NMCs are assigned a two number designation separated by a slant sign. The first number indicates the sequential number of the message correction to the original or revised publication. The last number is the printed change which will incorporate the material. For example, NMC 7/3 is the 7th message correction and will be incorporated into the publication by printed change number 3.

Watch-To-Watch Inventory

For positive control of NWPL publications, a watch-to-watch inventory should be used. The inventory format is left to the discretion of the individual command. A usable example is given in NTP 4. At the change of each watch, the watches will jointly conduct a sight inventory of every publication. Some loose-leaf publications require a page check at the change of the watch in addition to the sight inventory. The signing of the watch-to-watch inventory by the relieving watch certifies that the publications were sighted, the required page checks were conducted, and that the relieving watchstander is responsible for them. Any discrepancies should be resolved prior to relieving of the watch. All signatures in the watch-to-watch inventory must be in ink and the inventory may be destroyed after 30 days provided they are no longer needed for local reference. If watch-to-watch inventories are not required aboard ship, a daily inventory is required.

Extracts

When authorized by the Foreword or Letter of Promulgation of a publication, extracts may be made to disseminate information. Extracts must be assigned a classification based upon their contents. In other words, the classification assigned to an extract is the highest assigned to the articles, paragraphs, page, or pages from which the information is taken.

Receiving New or Revised Publications

When new or revised publications are received, the Foreword and the U.S. Letter of Promulgation should be checked for the effective status of the publication. The Foreword shows the effective status of the publication for Allied usage and the U.S. Letter of Promulgation for U.S. use. If a revision is promulgated to the publication that is effective for U.S. but not for Allied, particular care should be taken not to destroy the previous edition until the new revision is effective for allied use as well.

BASIC COMMUNICATION CENTER FILES

Maintaining accurate files and records and observing proper procedures contribute to an efficient shipboard or shore communication organization. It should be noted that different ships and stations may do basic things in slightly different ways, but all must conform to the necessities spelled out in communications operating instructions and NWPL publications that apply to these procedures.

Every message handled by a ship or station is placed in one or more files. Some files are maintained by all ships and stations, still others are optional and are maintained only to fill the need of a particular ship or station. The following is a list of the basic files maintained by all communication centers:

1. Communication Center File—Often referred to as the "CommCenter" file, it contains a copy or filler of every message sent or received by the command and processed by the communication center. Messages or fillers in the CommCenter file should be filed in date-time group (DTG) order to facilitate speed of location of messages. Those messages that do not have date-time groups should be filed behind messages for the same date.

2. Crypto-Center File—Contains a copy of each TOP SECRET or SPECAT (Special Category) message and such messages of any classification that the command designates for special privacy or handling. Messages are filed in DTG order and may be physically subdivided to comply with stowage requirements for classified matter. Fillers for all messages filed in the crypto-center file are placed in the communication center file.

3. General Message File—Contains a copy of all general messages that require retention by the command. This file is subdivided according to the individual titles of the general messages, e.g.; ALNAV, ALCOM, etc. General message files are filed in serial number order. Like all message files, the general message file may be segregated according to security classification or stowed and accounted for in accordance with the highest classification message contained within it.

4. Broadcast File—Contains a copy or filler of every message received via the broadcast method. Segregated stowage according to classification is not required for this file because it is maintained sequentially according to broadcast number and destroyed after ten days.

The importance of well kept files and of cooperation among the various watch sections to keep them that way cannot be overemphasized. Because of repeated reference to previously sent message traffic, all messages should be easily and quickly locatable. Always return a message to the same file from which it was removed and in the proper order of filing. When removing a message from a file, insert a filler in its place. The filler should list the True date-time group (TDTG), the message originator, information as to where the message may be located, and the personal sign of the person removing the message from the file and completing the filler.

Except for the general message file, any or all of the communications center files may be combined for ease of stowage, referencing and filing. The primary condition here is that separate stowage be afforded TOP SECRET messages, and in most cases, SPECAT. More detailed information regarding proper administration and retention periods of communication center files is contained in NTP 4.

Communications Logs

A communication log is a continuous record of everything that happens on a communication net or circuit. It can also be a record of all noteworthy events during a communications watch.

It is never permissible to erase an entry in any communication log. Necessary changes to communication logs are made by drawing a single, distinct line through the original entry and indicating the change next to it. The operator or supervisor making the change must initial all such changes. It is desirable that a log be as neat as possible and absolutely necessary that all logs be complete and totally accurate.

Supervisor Log

The supervisor's log is normally a typewritten record of all significant events occurring during the communications watch. The log covers an entire radio day, commencing at 0001Z. Because of the permanent and official nature of the supervisor's log, only standard terminology must be used for entries. The use of prescribed, authorized abbreviations is permissible and allows short concise entries so long as the abbreviations are commonly understood. Slang expressions and operator jargon shall not be used in log entries. Depending upon local requirements, entries are usually made in the supervisor's log at least once an hour, recapping the over-all traffic and circuit conditions.

Personal Signs

A personal sign is a two or more letter identification, usually the person's initials, and identifies his work on all logs and records. A personal sign may be regarded as your "signature". Your personal sign is never transmitted over communication circuits, but they are sent at the end of each transmission over order-wire circuits. The chief requirement regarding personal signs is that they must be legible.

DISPOSAL OF FILES AND LOGS

All communication files, logs, and reports are destroyed in accordance with the provisions set forth in SECNAVINST P5215.5 series and NTP 4. Proper disposal of these files and logs is a must and should be conscientiously carried out, when required. The only exception to the disposal periodicity is as follows for messages:

1. Messages incident to distress or disaster - Retain for at least 3 years.

2. Messages incident to or involved in any claim or complaint of which the command has been notified - Retain for at least 2 years or until the complaint or claim has been fully satisfied, whichever is later.

3. Messages of historical or continuing interest - Retain permanently.

COMMUNICATION TRAINING REQUIREMENTS

Wherever you go, as a third or second-class RM, you will find a necessity to learn new things and new methods as well as variations upon many things that you already know. Thus, communication training programs are necessary to ensure that the maximum number of personnel are sufficiently trained to handle any and all communications situations, in peacetime as well as combat situations. Never forget, training programs are not designed to simply take up time and fill in the working radio day; they are meant to foster and reinforce the knowledge of the individual so that he can contribute to the combat readiness of the ship or station, save lives, and aid the overall defense posture of the Armed Forces.

A command achieves maximum communication effectiveness when all personnel are thoroughly trained and qualified in installed systems. As a third or second-class involved in the communication division training, you will find that the overall provisions for general training and advancement are contained in the division or department Long Range Training Program. The Long Range Training Program includes all training for all communication personnel; both in and out of rate. You will find that an essential part of every training program is the effective cross-training of personnel in functional areas, so that all Radiomen are qualified to assume as many duties as possible in communication spaces. This is accomplished by periodically rotating personnel, allowing ample time for basic check-out prior to being relocated in that particular job.

Communications Checks and Inspections

In addition to communication training programs, periodic inspections are made of communication personnel to determine their professional proficiency. These checks, or inspections, may be initiated by the command or they may be initiated by an outside activity. They may be scheduled or unscheduled. An example of a scheduled check would be the yearly required visit by one of the Naval Security Groups (NAVSECGRUs). An example of an unscheduled inspection would be a periodic drill administered by the Leading Chief to determine on-watch readiness and operator proficiency. All inspections and checks usually cover personnel efficiency and performance in all areas in which they are trained, circuit operation by communication personnel, and informal quizzes, normally oral. Drills are normally a part of every inspection or check, thus requiring application of supposed knowledge that is "on paper". Therefore, whether the standpoint of an inspection, or a "real-world" situation, deriving maximum benefit from the training program aids the individual as well as all others concerned.

CHAPTER 10

COMMUNICATIONS SECURITY

Like many other words, the word "security" has more than one meaning. The general definition of security is "the safeguarding of classified material and information". Communications Security (abbreviated COMSEC) encompasses this general definition and further applies these general guidelines to the security of communications in particular. In the first part of this chapter, we will talk about security in general. Later, under its own heading, we will cover Communications Security, its definition, and how it differs from general security guidelines.

The security of the United States in general, and of naval operations in particular, depends in part upon the success attained in safeguarding classified information. Every Radioman must be security conscious to the point that exercising proper discretion in the discharge of all duties is automatic and not something separate and apart from other matters. During their daily work routine, Radiomen learn information of vital importance to the military and to the nation. Vast amounts of intelligence carried in messages handled by naval communications pass through the hands of Radiomen at some point. Much of this data, if available to our real and potential enemies, would enable them to learn much of the strength and intent of U.S. forces and gather a wealth of technical information relating to the procedures and operations of the United States Navy.

Radiomen have a two-fold job concerning security. The first, of course, is to properly discharge their duties pertaining to general security guidelines which pertain to everyone in every official capacity. Secondly, Radiomen must also discharge their duties in such a manner as to protect the integrity and overall value of secure communications. Naturally, much of the message traffic and publications handled and studied by Radiomen deal with communications matters. Their content must be protected because the more an enemy knows about our communications, the better his chances of deriving intelligence from them. There have been instances in which a potential enemy has obtained valuable information simply because those persons guarding it did not fully understand and appreciate what would constitute information of interest to a foreign power.

THE DANGER OF ESPIONAGE

Most nations, even in peacetime, maintain espionage organizations of varying size and scope for the purpose of seeking information regarding known or potential enemies. The activities of these organizations have always been among the greatest hazards to security.

Espionage is no longer an undertaking by a relatively few well-trained, isolated spies attempting to obtain military or naval information from high-ranking officers. It is a mass effort employed in all fields (military, political, economic, social, and cultural) by thousands of people in "minor" positions. Successful espionage depends upon statistical accumulation and slow, methodical compilation of seemingly insignificant bits and pieces of information until the total of it all tells a story. A single word or phrase used by someone in a seemingly harmless conversation may prove to be an important piece in the "jigsaw puzzle" the enemy is putting together.

During war or an extreme crisis, an enemy agent's primary objectives are to obtain and report as much valuable information as possible and to assist his government by spreading false reports, committing sabotage, directing invading forces, crippling key industries and utilities, seizing communication centers, exploiting vulnerable areas of defense, and undermining morale. Needless to say, it is not exaggerated to say that, even in peacetime, enemy espionage organizations present a serious threat to a nation's security.

The Navy is a potential source of valuable information, and unceasing, systematic attempts to exploit that source is in constant progress. The methods that may be used are many and varied: Planting agents within the naval establishment, photographing or stealing classified documents, tapping telephones and lines, attacking codes and ciphers, and analyzing communications personnel when off duty. Although bits of information obtained through these means often appear harmless, they prove to be of real value when subjected to expert and purposeful analysis combined with other fragments of information from various sources. The necessity for unceasing vigilance and maximum preventive measures on the part of all naval personnel and Radiomen cannot be too strongly emphasized. Security is a means, not an end. Rules that govern security of information do not attempt to meet every conceivable situation. With a proper command indoctrination program, it is possible to teach the minimum guidelines, instill proper security attitudes in all personnel, and obtain a satisifactory degree of secrecy with a minimum of sacrifices.

SECURITY CONTROL AND RESPONSIBILITY

The Chief of Naval Operations exercises control over all policies relating to the maintenance of the security of classified matter in the Navy and Marine Corps. The Commander, Naval Intelligence Command, owing to the close relationship of counterintelligence and preservation of security, is the officor primarily responsible to CNO for the promulgation of policies that relate to security of classified matter. The CNO has delegated to the Commander, Naval Security Group Command (COMNAVSECGRU) the authority for administering the Navy communications security program.

In order to provide for the proper indoctrination of all personnel charged with the responsibility for safeguarding classified matter, the Chief of Naval Operations has issued instructions that are necessary for the proper administration of the security system. Those instructions are contained in the effective edition of the Department of the Navy INFORMATION SECURITY PROGRAM REGULATION (OPNAV INSTRUCTION 5510.1).

SECURITY CLASSIFICATION CATEGORIES

Recently, a major change was implemented in the classifying and declassifying of security information promulgated within the Department of Defense. The objectives of the new system are to achieve the following:

1. Less official information will be classified.
2. More official information will be declassified.
3. Classified material will be better protected.

Each person named as a "classifying authority" is held accountable for the accuracy and necessity of the classification assigned by that person. Unnecessary classification and overclassification is to be avoided. Classification must be solely on the basis of national security considerations. Information is not supposed to be classified in order to conceal inefficiency or administrative error, prevent embarrassment to a person or department, restrain competition or independent initiative, or to prevent for any other reason the release of information which does not require protection in the interest of national security.

Official information or material which requires protection against unauthorized disclosure in the interest of national security is to be classified in one of three categories, TOP SECRET, SECRET, or CONFIDENTIAL, depending upon the degree of its significance to national security. No other categories are to be used to identify official information or material requiring protection in the interest of national security, except as otherwise provided by statute. Definitions and examples of each of the three categories appear in the following paragraphs.

Top Secret

"Top Secret" refers to that national security information or material which requires the highest degree of protection. The test for assigning Top Secret classification shall be whether its unauthorized disclosure could reasonably be expected to cause exceptionally grave damage to the national security. Examples of exceptionally grave damage are disclosures that would lead to:

1. Armed hostilities against the United States.
2. Compromise of vital national defense plans.

206

3. Compromise of complex cryptologic and communications intelligence systems.

This list is not all-inclusive, but it does show the relative degree of information that would fall into this category. The classification of "Top Secret" must be used with the utmost restraint.

Secret

The classification "Secret" refers to that national security information or material that requires a substantial degree of protection. The criteria for assigning Secret classification shall be whether its unauthorized disclosure could reasonably be expected to cause serious damage to the national security. The compromise of significant scientific or technological developments relating to national security would be examples of "serious damage". The classification Secret must be sparingly used.

Confidential

The classification "Confidential" refers to that national security information or material which requires protection. The test for assigning this classification shall be whether its unauthorized disclosure could reasonably be expected to cause damage to the national security.

SPECIAL MARKINGS

In addition to the three security classification categories, other markings also appear on documents and messages. Among these markings are such designations as RESTRICTED DATA, NOFORN, LIMDIS, EFTO and FOUO, and SPECAT. Included in the "special markings" category are those associated with the International Treaty Organizations, such as NATO, CENTO, and SEATO.

Restricted Data

The term "Restricted Data" means all data concerning the design, manufacture, and/or utilization of nuclear weapons. Also included in this category is the special nuclear material used in the production of energy. Included in the restricted data category is the term "Formerly Restricted Data". This sub-category pertains to defense information which has been removed from the Restricted Data category and cannot be released to foreign nationals except under specific international agreement.

NOFORN

The "NOFORN" designation means that a determination has been made that the information is not releasable in any form to foreign governments. The abbreviation NOFORN, which means "No Foreign Dissem", may be used only in messages and in automatic data processing of intelligence information. This designation, in long or short form, is not used in any other sense or on other than intelligence information. The absence of this designation is not to be construed as authorization to disseminate information to foreign nationals.

LIMDIS

The designation "LIMDIS" (meaning limited distribution) is used to limit distribution of copies of such messages to those personnel specifically authorized to have access to that information on a need-to-know basis.

EFTO and FOUO

Certain categories of unclassified messages must be designated EFTO (Encrypt for Transmission Only) and given cryptographic protection during transmission. EFTO is not used as protection for messages containing classified information; such messages shall be appropriately classified.

FOUO (For Official Use Only) messages are certain categories of official information which require some degree of protection for the good of public interest, but are not safeguarded by a classification category in the interest of national security. There are several markings combining EFTO and FOUO. For example, FOUO information which is to be transmitted outside CONUS is marked "EFTO". The first words of the text will be marked "UNCLAS EFTO FOUO". Bear in mind, however, that because information is FOUO, it is not automatically EFTO, and vice versa. As previously mentioned, EFTO is a transmission marking for unclassified messages; FOUO markings define a certain category of information requiring special handling. Neither is a security classification; both are special handling designations. More detailed information on EFTO and FOUO markings can be found in NWP 4.

SPECAT

The marking "SPECAT" means "special category" and requires special handling procedures in addition to the security classification assigned. Processing of this type of information is restricted to only those personnel authorized to view it as approved by the commanding officer, in writing. Types of information assigned this marking can be found in NWP 4.

Markings of International Treaty Organizations

Defense information of a classified nature furnished to the United States or to naval communications by a foreign government or international treaty organization is assigned a classification which will assure a degree of protection equivalent to, or greater than, that required by the government or international organization which furnished the information. Examples of international treaty organizations are NATO, CENTO, and SEATO.

In general, foreign security classifications parallel U.S. classifications. However, many foreign governments and international treaty organizations use a fourth security classification: "RESTRICTED". Information designated Restricted indicates in English the name of the foreign government or organization of origin prior to the word Restricted. For example; "UK - RESTRICTED" or "NATO - RESTRICTED". Materials in this category are treated as Confidential. Equivalent security markings as compared to those of the U.S. are contained in OPNAVINST 5510.1( ).

GENERAL DECLASSIFICATION SCHEDULE

Unless specifically exempted, classified information and material is assigned a date or event on which it will be downgraded and declassified. This downgrading and declassification is done in accordance with the General Declassification Schedule as described in the following paragraphs.

Top Secret

Top Secret information and material is downgraded to Secret two calendar years after origination, downgraded to Confidential four years after origination, and declassified ten years after origination. For example, a document classified Top Secret on 2 February 1976 will automatically be downgraded to Secret on 31 December 1978, downgraded to Confidential on 31 December 1980, and declassified on 31 December 1986.

Secret

Information and material originally classified Secret is automatically downgraded to Confidential at the end of the second full calendar year in which it was originated, and declassified at the end of the eighth full calendar year following the year in which it was originated. For example, a document classified Secret on 26 May 1976 will be downgraded to Confidential on 31 December 1978 and declassified on 31 December 1984.

Confidential

Confidential information and material is declassified at the end of the sixth full calendar year following the year in which it was originated. For example, a message originally classified Confidential on 16 July 1976 will be automatically declassified on 31 December 1982.

Exemptions From The General Declassification Schedule

In some instances, certain classified information or material may warrant some degree of protection against unauthorized disclosure for a period of time exceeding that provided in the General Declassification Schedule. However, although the provision is made for such instances, it is a category that is used sparingly and must fall into one of the four categories listed in OPNAVINST 5510.1( ). In addition, whenever broad categories of Top Secret information are to be placed into one of the exemption categories, specific permission must be obtained from the Director of Naval Intelligence (DNI).

Declassification Markings on Messages

As a Radioman, you will need to be familiar with various message markings. Learning all of the markings and their meanings requires much study and experience. However, one of the more recent changes to message markings involves the placement of downgrading and declassification markings into the body of a naval message.

As a rule, the last line or paragraph of a classified message will show one of the following markings to determine downgrading and declassification of that message:

1. "ADS ( )" - For messages assigned to the Advanced Declassification Schedule. For example, a message bearing the marking "ADS (26 May 76) indicates that the message will be declassified on 26 May 1976. Advanced Declassification is used whenever the information contained in the message need not be classified for the periods of time specified under the General Declassification System.

2. "GDS ( )" - For messages assigned to the General Declassification Schedule. For example, a message bearing the marking "GDS(84)" indicates that the message will be declassified at the end of the calendar year 1984.

3. "XGDS ( ) ( )" - For messages exempted from the General Declassification Schedule. The first parentheses contain the exemption category from OPNAVINST 5510.1( ). The second parentheses contain the last two digits of the calendar year in which the message is to be declassified. The second parentheses are not always used because it is not always known how long the material will require exemption from declassification. For example, "XGDS (02) (84)" indicates that the message is exempted from the General Declassification Schedule, falls under exemption category 2, and will be declassified at the end of the calendar year 1984.

4. "XCL ( )" - For messages that have been reviewed and re-marked, and that previously bore the Group 1, 2, and 3 markings. Examples of these elder markings are "GP1, GP2, GP3". GP1 and GP2 marked materials were normally excluded from automatic downgrading and declassification. GP3 material was automatically downgraded but not automatically declassified. Normally, GP1 and GP2 materials would bear the "XGDS" marking, but because they were previously marked under the older system, they bear the marking "XCL". This marking identifies the material as having been reviewed. The parentheses identify all Group 3 material that has been reviewed and a date for downgrading determined. For example, the marking "XCL (84)" means that the material is formerly "Group" marked, is GP3 material, and will be downgraded at the end of the calendar year 1984.

Complete information on the marking and remarking of classified messages is contained in OPNAVINST 5510.1( ).

General Marking Requirements

Classified documents and material which contain identifiable classified information must be clearly and conspicuously marked. In addition, special markings such as NOFORN, LIMDIS, RESTRICTED DATA, etc. are normally placed near the classification marking. Markings required for classified material serve to inform and warn recipients of the classification assigned, indicate the level of protection required, and identify that information which must be withheld from unauthorized persons.

The classification markings of TOP SECRET, SECRET, and CONFIDENTIAL shall be stamped, printed, or written in capital letters (not typing alone) that are larger than those used in the text of the document and, when practicable, red in color.

All reproductions or copies of classified materials, regardless of form, shall bear clearly legible security classification markings and notations in the same manner as on the original material from which they are copied or reproduced. It should be noted here that copying equipment does not always clearly reproduce all colors of ink or marginal images. Therefore, if the reproduction process does not clearly reproduce the security markings appearing on the original copy, such markings shall be stamped on all copies in the same positions and size required for the original.

Paragraph markings are commonplace and are found immediately preceding and to the left of the part involved. The symbols denoting paragraph classification are (TS) for Top Secret, (S) for Secret, (C) for Confidential, and (U) for Unclassified. When appropriate, the symbols (RD) for Restricted Data and (FRD) for Formerly Restricted Data are used. It is not uncommon to see foreign originated information in U.S. documents and indicated as such next to the applicable paragraphs or parts. For example, "U.K.(C)" or "NATO(S)".

Titles and subjects are classified according to their content, standing alone, regardless of the overall classification of the document. Normally, the initials of the classification assigned to a title or subject are indicated in the parentheses immediately following the item. For example, BASIC OPERATIONAL COMMUNICATIONS DOCTRINE (U). Complete information on paragraph, sub-paragraph, document marking, etc., is contained in OPNAVINST 5510.1( ).

SECURITY AREAS

Different spaces on-board ship and different areas within a shore activity may have varying degrees of security importance depending upon their purpose and the nature of the work, information, or materials concerned. To meet this situation and, at the same time, facilitate operations and simplify the security system require the application of restrictions, controls, and protective measures commensurate with these varying degrees of security importance. In some cases, the entire area of an activity may have a uniform degree of security importance requiring only one level of restriction and control. In others, differences in the relative degree of security importance will require total segregation of ship's spaces or activity areas.

In order to meet the varying needs of the different levels of security sensitivity, three different types of security areas are used: EXCLUSION, LIMITED, and CONTROLLED. These three areas provide a relatively effective and efficient basis for applying varying degrees of restriction dealing with access, control of movement, and the type of protection required. The various security areas are defined as follows:

1. EXCLUSION AREA - An area containing classified information or material which is of such a nature that mere access to the area constitutes, for all practical purposes, access to such information or material.
2. LIMITED AREA - An area containing classified information or material and in which uncontrolled movement would permit access to such information or material, but an area in which access may be prevented by escort and other internal restrictions and controls.
3. CONTROLLED AREA - An area within which uncontrolled movement does not permit access to classified information or material, and which is used principally for providing administrative control, safety, or a buffer area of security restriction for limited or exclusion areas.

With the exception of exclusion areas, security areas are not always marked in such a manner as to determine their relative sensitivity. In other words, controlled areas are not always marked with a sign saying "Controlled Area". All such areas (Exclusion, Limited, Controlled) are normally marked by signs reading "RESTRICTED AREA - KEEP OUT - AUTHORIZED PERSONNEL ONLY". In areas where a language other than English is prevalent, the warning notices are rendered in both English and the local, legal language(s).

Access Badges

To provide the degree of security required for access to particular security areas, a pass or badge identification system is normally established at each command to facilitate control of movement. Control of movement within the area is normally monitored by a security guard(s) or operating personnel by requiring the display or presentation of the badge for that particular area.

Access and Dissemination

In addition to holding a proper security clearance, the requirement that classified information be limited strictly to those persons whose official military or government duties require knowledge or possession is simply termed as "need to know". You will find the term "need to know" used frequently in communications. This term should always be evident whenever you are dealing with access to or dissemination of classified information or material.

Admitting unauthorized personnel to communications spaces is a topic of major concern to a Radioman. Merely because a person has a badge does not necessarily mean that he has access or the "need to know". This is especially important since access to communications spaces under operating conditions usually permits viewing of classified operational traffic and equipment. In addition to the much-used badge identification system, admission of personnel to communication spaces is granted only to those personnel whose names appear on a proper access list. Access lists are posted at the entrance to communication spaces and are signed and approved by the commanding officer. Admission of persons other than those on the access list is subject to the specific approval of the commanding officer or his designated representative.

Persons not on the access list, but who have been specifically granted permission by the commanding officer for entry, are escorted or supervised at all times while in communication spaces. Though not classified, access lists are handled with the same degree of security required for the particular area to which they pertain.

The final responsibility for determining whether a person is granted access rests upon

210

the individual. No amount of written rules or governing statutes can replace individual initiative and common sense. Finally, no one has a right to access based solely upon rank or position.

HANDLING AND STOWAGE OF CLASSIFIED MATERIAL

Within each command, specific control and accountability procedures are established to provide readily available information on classified material. Such information includes what classified information or material has been received, what classified material has been produced, who has custody, and what disposition has been made of the material.

To control classified information with maximum efficiency, the commanding officer designates a Command Security Manager, usually an officer. In addition, the commanding officer usually appoints a Top Secret Control Officer (TSCO). The Top Secret Control Officer is normally subordinate to the Command Security Manager. If a separate person is not assigned each duty, one person may be assigned to perform the duties of both. The duties of the Security Manager and the TSCO are governed by the rules outlined in OPNAVINST 5510.1( ).

Handling of Top Secret Material

Although administrative records are maintained for each classification category, a more strict control system is required for Top Secret material.

Except for publications containing a distribution list by copy number, all copies of each Top Secret document and each item of Top Secret equipment are numbered serially at the time of origination:

Copy No.___of___Copies.

Each page of a Top Secret message not containing a list of effective pages (LOEP) is numbered:

Page___of___pages.

Top Secret documents have a list of effective pages and a page-check page.

Top Secret documents may be reproduced in whole or in part only with the permission of the originator or higher authority. All reproduced copies are numbered serially and recorded with the TSCO so as to maintain complete accountability. The copy numbers of reproduced copies should maintain a relationship with the original document. For example, if a command holds copy No. 12 to a Top Secret document and reproduces two additional copies, the latter might be identified as "Copy No. 12/1 of 2 copies" and "Copy No. 12/2 of 2 copies".

A continuous chain of receipts for Top Secret material must be maintained. Moreover, a record of disclosure for Top Secret material, using OPNAV Form 5511-13, is attached to each document that circulates within a command or activity. Every person having knowledge of the contents of the TS document must sign the attached record of disclosure.

Every command is required to establish administrative procedures for recording all Secret material originated and received. These administrative procedures as a minimum, must include system of accountability for Secret matter distributed or routed within the command. Additionally, as a minimum, every command must maintain a system which will provide for protection of all Confidential material originated or received.

CUSTODIANS OF CLASSIFIED MATERIAL

An individual who has possession of or is charged with the responsibility for safeguarding and accounting for classified material or information is referred to as the "custodian" of that material or information. That person is said to have "custody" of the material or information.

Whenever you are the custodian of classified material, you are responsible for providing protection and accountability at all times and particularly for locking classified material in the appropriate security container whenever it is not in use or under direct supervision.

Care During Working Hours

Each individual must take precautions to prevent access to classified information by unauthorized persons. Among the precautions to be followed are:

1. When removed from storage for working purposes, classified documents are to be kept

under constant surveillance and face down, or covered when not in use.

2. Preliminary drafts, carbon sheets, plates, stencils, stenographic notes, worksheets, and all similar items containing classified information must be either (1) destroyed by the person responsible for their preparation immediately after they have served their purpose, or (2) be given the same classification and safeguarded in the same manner as the classified material produced from them.

3. Typewriter ribbons used in typing classified material are protected in all respects in the same manner as the highest level of classification for which they have been so used. When destruction is necessary, it is accomplished in the manner prescribed for classified working papers of the same classification. After the upper and lower sections have been cycled through the machine five times in the course of regular typing, all fabric ribbons are considered unclassified. Carbon and plastic typewriter ribbons and carbon paper which have been used in the production of classified information are destroyed in the same manner prescribed for working papers of the same classification after initial usage.

Care After Working Hours

At the close of each watch or working day, all classified material that must be passed from watch to watch is properly inventoried and custody is then transferred to the relieving watch supervisor. All other classified material must be locked up. A system of security checks at the close of each working day is the best method to ensure that all classified material held is properly protected. The custodian of the material should make an inspection which ensures as a minimum that:

1. All classified material is stored in the manner prescribed.
2. Burn bags are properly stored or destroyed.
3. The contents of wastebaskets which contain classified material have been properly stored or destroyed.
4. Classified shorthand notes, carbon paper, carbon and plastic typewriter ribbons, rough drafts, and similar papers have been properly stored or destroyed. As a matter of routine, such items should be placed in burn bags immediately after they have served their purpose.

Stowage of Classified Material

All classified matter not in actual use must be stowed in a manner that will guarantee its protection. The exact nature of security requirements depends on a thorough security evaluation of local conditions and circumstances. Also, the degree of protection necessary depends on the classification category, quantity, and scope of the material involved. Normally, the type and extent of physical protection required are determined before an activity begins its day-to-day or watch-to-watch routine, and it is very likely that an appropriate physical security program is already in effect when you report aboard. Details concerning physical security standards and requirements which serve as a guide for determining the kind and degree of physical protection necessary for classified information are contained in the applicable edition of OPNAVINST 5510.1( ).

Whenever you secure classified material in safes, habitually rotate the dial of all combination locks at least four complete turns in the same direction. If dials are given only a quick twist, it is possible to open the lock by turning the dial in the opposite direction.

All safes and cabinets which contain classified matter that are found open and unattended should be reported to the senior duty officer. Do not touch the container or contents, but guard them until the duty officer arrives. The duty officer then assumes responsibility for such further actions as locking the safe, recalling the responsible person or persons, and reporting the security violation to the commanding officer. The custodian must hold an immediate inventory of the contents of the safe and report any loss to the commanding officer.

Combinations

Combinations to safes containing classified material are made available only to those persons whose duties require access to them. The combinations of safes containing classified information must be changed at least every 12 months, unless more frequent change is dictated by the type material stored within. Combinations must also be changed:

1. When placed in use after procurement.
2. Whenever an individual knowing the combination is transferred, discharged, or reassigned from the element to which the security container is assigned, or the security clearance

of an individual knowing the combination is reduced, suspended, or revoked by proper authority.

3. When the combination or the record of the combination has been compromised or the security container has been discovered unlocked and unattended.

The combination of a security container used for stowage of classified material is assigned a security classification equal to the highest category of classified material authorized to be stored therein. Records of combinations are sealed in an envelope and kept on file in a central location designated by the commanding officer.

DESTRUCTION OF CLASSIFIED MATERIAL

Destruction of superseded and obsolete classified materials that have served their purpose is termed routine destruction. Classified material that is no longer required should not be allowed to accumulate. There are specific directives that authorize the routine destruction of publications, message files, and certain crypto materials. These directives should be carefully studied and become part of the Radioman's store of knowledge in order to properly comply in all cases. Additionally, the letter of promulgation of publications often set forth disposition instructions regarding destruction requirements for that publication. Other materials, such as classified rough drafts, worksheets, and similar items, are destroyed as necessary to prevent their excessive accumulation.

Top Secret, Secret, and Confidential material may be destroyed by burning, pulping, pulverizing, or shredding, provided the destruction is complete and that reconstruction will be impossible. The most efficient method of destroying combustible material is by burning.

As a third or second class petty officer, you will more than likely either assist in or supervise the burning of classified material. Every member of a burn detail should know exactly what is to be burned and should double check each item before it is burned. To provide accountability of the burn bags, the bags are numbered (or at least counted) prior to being removed from the work spaces. The supervisor of the burn is provided a log or checkoff list which lists the number of bags to be burned. At the destruction site, each bag is checked off the list as it is destroyed. To facilitate complete destruction of bound publications, the pages must be torn apart and crumpled before being placed in bags. All material must be watched until it is completely consumed. The ashes must be broken up and scattered so that no scraps escape destruction. When no incinerator is available, which is often the case aboard ship, classified material may be burned in a perforated metal drum or container with a cover of wire netting.

Shredders may be used aboard ships at sea where incinerator facilities are not available under the following conditions:

1. The maximum shred width allowed shall be 1/32 of an inch.
2. Cryptomaterial shall be intermixed with at least an equal amount of other material (classified or unclassified) prior to shredding.
3. The material is then disposed of by jettisoning at a time and place where recovery by hostile forces is considered by the commanding officer to be unlikely.

Proper destruction of classified material is accomplished in the presence of two witnessing officials. Witnessing officials must have a security clearance of at least as high as the category of material being destroyed, and they must be thoroughly familiar with the regulations and procedures for safeguarding and destroying classified information.

An accurate record of destruction of classified material is as important as the destruction itself. Proper accounting procedures, together with accurate records of destruction, provide official information as to the status of classified material. Records of destruction are required for Top Secret and Secret material and shall be dated and signed by the witnessing officials unless the material has been placed in burn bags for central disposal. In that case, the destruction record shall be signed by the witnessing officials at the time the material is placed in the burn bags. Records of destruction shall be maintained for a minimum of two years after which they may be destroyed.

Emergency Plans

Emergency plans are developed by each command in order to provide for the protection, removal, or destruction of classified material. Needless to say, emergency plans are tailored to fit the needs of that particular command, so there is no "right" way of developing a usable one. The primary requirement is that these plans adequately provide for rapid and complete disposition of the classified material held by the command. Emergency plans should be developed to cover three areas of emergencies:

1. Natural Disasters (e.g., hurricanes).
2. Civil Disturbance (e.g., rioting).
3. Enemy Action.

Emergency plans should provide for the protection of classified information and material in such a manner as to minimize the risk of loss of life or injury to personnel. This can be accomplished in several ways whenever the emergency plan is implemented:

1. The coordinated and expeditious execution of the plan itself.
2. Perimeter, preinstructed "guard" personnel at various positions in affected areas, trained to prevent the removal of classified material by unauthorized personnel.
3. Periodic review and constructive update of emergency plans in order to provide for the safety of personnel and classified material.

Whenever the emergency plan is implemented for the purpose of material destruction, you will normally find the following required priorities assigned to material to be destroyed:

1. FIRST PRIORITY - Communication Security (COMSEC) material and classified components of equipment.
2. SECOND PRIORITY - Top Secret special access material, then other Top Secret material.

3. THIRD PRIORITY - Secret special access material, then other Secret material.

4. FOURTH PRIORITY - Confidential special access material, then other Confidential material.

5. FIFTH PRIORITY - Unclassified equipment which could be of use to the enemy together with pertinent technical, descriptive, and operating instructions.

Fire Plans

In addition to emergency plans, a plan of action in the event of fire is also a necessity. As with emergency plans, it is imperative that all communications personnel familiarize themselves with the command "Fire" plan. Normally, the fire plan includes provisions for:

1. Local fire-fighting apparatus and personnel to man the equipment.
2. Evacuation of the area, including whether to store or remove classified material from the area.
3. Admitting outside fire-fighters into the area.

Precautionary Actions

Needless to say, the fewer actions necessary in emergencies, the better off you are. Therefore, all that can be done before an emergency occurs should be done. For example:

1. All superseded material should be destroyed immediately after supersession.
2. Only the minimum amount of classified material should be held by a command, consistent with its needs.
3. Unnecessary material should be turned in to the issuing agencies.
4. Material should be stored in such a way as to make it readily accessible and easy to reach for removal during destruction.

Sometimes, the commanding officer has been previously informed of a pending disaster, civil action, or enemy threat and has ample time to prepare. In such cases, "Precautionary Destructions" are held. "Precautionary" destructions are accomplished in order to reduce the amount of classified material on hand in the event emergency destruction later becomes necessary. Destruction priorities remain the same during precautionary action. However, when precautionary destructions are held, that material essential to communications must be held and not destroyed. For example, communications operating procedures and publications that are to become effective in the near future, and those that are already effective and used on a continuing basis and are necessary to basic operations would not be destroyed.

COMMUNICATIONS SECURITY (COMSEC)

Naturally, security guidelines contained in applicable publications, such as OPNAVINST 5510.1( ), must be complied with by everyone. These guidelines are minimum standards and must be complied with, and all other security procedures start there.

Your job often deals in very sensitive subject matter that requires special security procedures and precautions. It is for this reason that we have the term "Communications Security" (COMSEC). Within the framework of communications security, we find many directives and requirements that deal specifically with communications material.

Communications security is defined as "The protection resulting from all measures designed to deny unauthorized persons information of value which might be derived from the possession and study of telecommunications". That definition can also be extended to include all efforts to mislead unauthorized persons in their interpretations of the results of their possession and study. In sum total, the overall effort to protect the integrity and validity of our communications community.

COMSEC includes:

1. Cryptosecurity.
2. Transmission security.
3. Emission security.
4. Physical security of communications security materials and information.

The related definitions of the four areas of COMSEC are as follows:

1. Cryptosecurity - That security resulting from the provision of technically sound cryptosystems and their proper use.
2. Transmission Security - That security resulting from all measures designed to protect transmission from interception and exploitation by means other than cryptoanalysis, (e.g., messenger, approved wire circuits, ordinary mail, radio).
3. Emission Security - That security which results from all efforts to deny our enemies interception and analysis of compromising emanations from cryptoequipment and telecommunications equipment.
4. Physical Security - That security which is designed to prevent COMSEC information from being physically lost, exposed, or possibly exposed to an unauthorized person.

Anytime an unauthorized person or persons gain access to classified information requiring protection, a COMPROMISE is said to have occurred. A compromise normally results from a violation of one of the rules and standards governed each of the previously mentioned areas of COMSEC.

In the area of COMSEC, it is important to understand the difference in terminology—for example, the terms "COMSEC Information" and "COMSEC Material". COMSEC Information includes all information concerning communications security and all material associated with the security or authenticity of telecommunications. COMSEC Material includes all documents, devices, equipment, or apparatus used in establishing and maintaining secure communications. Therefore, it can be said that everything can be considered "information", whereas "material" is a relatively physical definition. It may seem to be a fairly insignificant point, but in COMSEC there are very precise definitions that define separate categories with necessary clarity. The categories of COMSEC are many and all deal with the security of communications or related items. Most often, the information known or the material used is highly classified and can prove very harmful to the national defense effort if compromised. More than simply defining the four categories of COMSEC, the related items and categories must also be defined. A few of the items and subcategories are defined and explained in this chapter, although they are not all-inclusive. Complete terms, areas, items, and subcategories can be found in the applicable editions of KAG 1, CMS 4, and NWP 4. The following is a list of definitions and explanations involving some of the more commonly used terms in communications security that you will use often in your career as a Radioman.

COMSEC Material Control (CMS) System

The CMS system is a system designed to ensure the proper distribution, handling, control, and security of COMSEC material used to maintain the cryptographic security of communications throughout the naval establishment. Consequently, the material governed by CMS procedures consists of highly sensitive, classified material and less sensitive but related material. With the correct usage of this system, the integrity and security of COMSEC material can be maintained. Procedures governing this system can be found in the applicable edition of CMS 4.

Accountability Legend

An accountability legend (abbreviated AL) is a number that is assigned to COMSEC material. It governs the method by which that material must be accounted for. For example, a piece of COMSEC material that is assigned the accountability legend "1" (written AL 1) is afforded a different handling procedure with regard to stowage and protection than, say, a piece of COMSEC material bearing the accountability legend "4" (written AL 4). Accountability legends, their definitions and handling requirements, are contained in the applicable edition of CMS 4.

CMS Holders

Every command that has a CMS account is assigned a number corresponding to that account. By being a command or activity which has an account number, it means that that particular command receives its COMSEC material directly from national and Navy distribution sources. However, a "Holder" in the CMS System is defined as any command or activity that is authorized to draw and hold COMSEC material. Naturally, once held, an account number is assigned to that command.

A CMS "Local Holder" is a command or activity whose COMSEC material needs can be met by drawing the material from a single CMS account on a local custody basis. In other words, if a ship drew all of its COMSEC material from a central account maintained by the Squadron Commander, the ship would then become a "local holder".

A CMS "Responsible User" is normally someone within the command who signs for the CMS material on a local custody basis and is then responsible for its proper handling and use. For example, the Operations Officer may need several COMSEC publications to aid in his departmental efforts. He would receive the material from the CMS Custodian by officially signing for it and, therefore, assuming all responsibility for it. He is considered a "responsible user".

Within the CMS System, there are many terms that are important to personnel who maintain and use the tools of it. The terms previously defined are only a few of the more commonly used ones. Needless to say, time and space preclude our listing them all here. A thorough discussion of each and every area and term used in the CMS System is contained in the applicable edition of CMS 4, the governing pub for the entire system.

CRYPTO

As a Radioman, you will be required to learn and understand all of the more detailed procedures and processes involved in cryptographic operations. These procedures and associated equipments are governed by many strict rules and standards. In order to later grasp the significance of cryptographic operations and their importance, you must first understand the defined elements of CRYPTO and the more common usages in terminology.

Cryptomaterial

The term "Cryptomaterial" refers to all material, including documents, devices, or apparatus, that contains crypto-information. The material must further be essential to the encryption, decryption, or authentication of telecommunications. Cryptomaterial is always classified and is normally marked "CRYPTO". The term "CRYPTO" is not a security classification; it simply denotes that the material requires special consideration with respect to access, storage, and handling.

Cryptorelated Information

Cryptorelated information may be classified or unclassified and is normally associated with cryptomaterial but is not significantly descriptive of it. In other words, it does not describe a technique or process, a system, or equipment functions and capabilities. Related information is not marked "CRYPTO" and is not subject to the special safeguards normally associated with crypto-information.

Crypto-Information

Crypto-information is always classified. This type of information normally concerns the encryption or decryption process of a cryptosystem. It is normally identified by the marking "CRYPTO" and is subject to all of the special safeguards required by that marking.

Cryptosystem

The term "cryptosystem" encompasses all of the associated items of cryptomaterial that are used together to provide a single means of encryption and decryption.

Needless to say, all items of a related nature that combine to form a system must be given the strictest security. Any failure, whether it be equipment or operator, which adversely affects the security of a cryptosystem, is called a "crypto-insecuriy".

Crytpomaterial which supplies equipment settings and arrangements or which is used directly in the encryption and decryption process, is called "KEYING MATERIAL". Keying material is afforded the highest protection and handling precautions of all information and material within a cryptosystem. Keying material is always given priority in the event of implementation of the emergency plan, whether precautionary or emergency.

Cryptovariables

A cryptovariable is an element of a cryptosystem that directly affects the encryption and decryption process. These variables are divided into two types: Primary and secondary. A primary cryptovariable is the most readily and frequently changed element of a cryptosystem. A secondary cryptovariable is one which permits change of circuit operation without altering the basic equipment. A secondary cryptovariable must also be used in conjunction with appropriate primary variables.

CRYPTOGRAPHIC DUTY

The commanding officer is the person responsible for ensuring that personnel are thoroughly trained and certified as qualified for cryptographic duties. This training may be accomplished through formal cryptographic schooling or through "on-the-job" training which is normally provided by the command's COMSEC officer. No member of the medical, dental, medical service, nurse, chaplain, or hospital corps may be assigned to duty that involves the processing of message traffic in classified communications spaces.

Operator Requirements

The COMSEC officer is responsible for ensuring that cryptographic operators receive the basic training necessary to these operations, as well as ensuring that they meet the following minimal qualifications:

1. That they be properly cleared for access to the material with which they will be working.
2. That they have normal eyesight and manual dexterity.
3. That they are authorized by the commanding officer to perform cryptoduties in his command.
4. That they are familiar with local cryptoprocedures.

General and Specific Cryptosystems

In the course of your cryptographic duties, you will sometimes hear the terms "general" and "specific" applied to some cryptosystems. A general cryptosystem is one which consists of a basic principle and method of operation regardless of the cryptomaterials employed. In other words, regardless of the types of materials or elements used, the method of operation will always be the same, whether encrypting, decrypting, or authenticating.

A specific cryptosystem is one within a general system that is necessary and confined to actual encryption, decryption, or authentication. These systems are identified by the short and long titles of their variables.

COMSEC DESTRUCTION

In addition to the requirements discussed in the effective edition of OPNAVINST 5510.1( ), the priorities and methods of destruction of COMSEC material are also discussed at length in KAG 1 and CMS 4. It is because of the extreme sensitivity of COMSEC material that separate, more detailed guidelines regarding stowage and destruction are written. As a third or second-class Radioman, you will become intimately involved with the procedures governing both in your daily routine, whether ashore or at sea, The communication center destruction plan is usually very detailed and concise, outlining destruction actions on a billet-by-billet basis.

COMSEC Destruction Priorities

COMSEC material which will need to be destroyed in an emergency can be divided into three categories:

1. Keying material.
2. COMSEC documents.
3. COMSEC equipments.

The most sensitive, of course, is keying material. Keying material is always destroyed first, but in a distinct order, as follows:

1. Superceded
2. Reserve
3. Effective

The most sensitive keying material is that which has been used to encrypt traffic. Normally, this keying material is superceded, and if it falls into enemy hands, all past traffic intercepted by them would then be subject to compromise and analysis.

Next in the order of destruction is keying material which will become effective within the next thirty days. After this is accomplished, the remaining keying material is then destroyed. It should be noted that in lining up keying material for destruction, Top Secret material should be placed ahead of Secret, Secret ahead of Confidential, etc. This applies to all of the categories of keying material.

Included under the category of COMSEC documents, are crypto-equipment maintenance manuals, operating instructions, general publications, such as KAG 1, status publications, holders lists and directories, etc. These documents contain useful information concerning the types of crypto-equipments we use, the level of technology we have attained, and the way our COMSEC operations are organized and conducted.

In emergencies, the immediate goal with regard to crypto-equipment is to render the equipment unusable and unrepairable, so as to deny the enemy a useful piece of equipment. The operating and technical manuals for crypto-equipments detail the techniques for rapid and effective destruction of them.

The emergency destruction of all COMSEC material and information would be a very detailed operation. Primary in this operation, of course, is the already-discussed keying material. The remaining priorities after the keying material are treated in detail in the effective editions of CMS 4 and KAG 1.

The destruction plan itself is contained in the overall "Emergency Plan". The Emergency Plan should always provide for one of three options, depending upon the situation:

1. Securing the material,
2. Removing the material, or
3. Destroying the material.

When to choose which course of action should be stated in the overall plan. For example, if there is a local civil uprising which appears to be short lived, destroying all material would probably not be necessary. In this situation, a partial destruction of the more sensitive superseded material might be implemented, some of the remaining material removed, and the rest secured. In any case, the commanding officer will normally implement the emergency plan. Should the situation prevent contact with the commanding officer, several other responsible individuals such as the COMSEC officer or COMSEC custodian are usually empowered to implement the emergency plan.

EMISSION CONTROL (EMCON)

EMCON is defined as the control of all electromagnetic radiations. At times, the operational requirement may demand that all electromagnetic radiations be kept to a minimum, consistent with operational necessity. Once imposed, general or specific restrictions may be added to the EMCON order, depending upon the operational, intelligence, or technical factors for the area affected.

The most secure communications methods during EMCON reduce (but do not eliminate) the possibility of identification. It is assumed that any electromagnetic radiation will be immediately detected and the position of the transmitting ship will be fixed by the enemy. Detailed information concerning the implementation of EMCON and its degree of adjustment are found in NWP 33.

MEACONING, INTERFERENCE, JAMMING, AND INTRUSION (MIJI)

The term "MIJI" is actually comprised of four different ones. Each term within MIJI has a separate and distinct definition, with separate methods of combatting each. It is a term intended to cover all of the basic types of interference that you are likely to experience in a given situation.

Meaconing is defined as the interception and rebroadcast of beacon signals. These signals are rebroadcast on the received frequency to confuse enemy navigation. Consequently, aircraft or ground stations are given inaccurate bearings. Meaconing is more of a concern to personnel in navigational ratings than to you as a Radioman. However, communications transmitters are often used to transmit navigational signals and are operated by communications personnel who must know how to deal with any communication situation resulting from meaconing.

Interference is normally a non-deliberate intrusion upon a circuit and may be defined as any electrical disturbance which causes undesirable responses in electronic equipment. "Harmful" interference may be defined as any emission, radiation, or induction which endangers the functioning of a radio navigation service or radio communications service that is operating in accordance with international regulations. For communication purposes, the term "interference" is that type of interference which precludes the effective use of a frequency. It does not include interference that is merely an annoyance.

Jamming is defined as the deliberate use of electromagnetic signals with the object of impairing communication circuits. The types of jamming are:

1. Random-keyed
2. Continuous wave
3. Sweep-through
4. Stepped-tones (Bagpipes)
5. Spark
6. Rotary

The methods of jamming may include the introduction of simulated traffic, random noise, or a continuous carrier.

Intrusion is defined as any attempt by the enemy to enter the U.S. or Allied communications systems and simulate our traffic in order to confuse and deceive.

The more effective methods of dealing with each of the types of interference contained in the term "MIJI", are contained in the effective editions of NTP 4 and NWP 33.

AUTHENTICATION

Authentication is a security measure designed to protect a communications or command system against fraudulent transmissions or simulation. In communications, only those approved authentication systems may be used. ACP 122 sets forth the situations when authentication is either mandatory or merely advisable.

SECURITY VERSUS SPEED

In communications, a variable relationship exists between security and speed. For example, in the planning stages of an operation when very few people are informed as to the plan, security is paramount. As the time of execution approaches, additional personnel must know of the plan, and preparations cannot be concealed so effectively. Then, speed becomes increasingly important. In combat situations, the relationship between security and speed will vary, depending upon operational considerations. For example, if it was of paramount importance that a Top Secret message be sent over non-approved wire lines in order to facilitate an operation with minimum loss of lives, the operational commander might decide that the speed necessity overrides security considerations.

NAVAL SECURITY GROUPS (NAVSECGRUs)

Within the general COMSEC organization, it can be said that the Chief of Naval Operations, (CNO) has the overall authority for COMSEC policy in the naval establishment. Naturally, the COMSEC program is only one of many that the office of the Chief of Naval Operations must oversee. Therefore, the specific responsibilities for implementation and administration of large programs (such as COMSEC) are overseen by specific agencies within the office of the CNO. This particular job is handled by the Commander, Naval Security Group Command (COMNAVSECGRU). COMNAVSECGRU reports directly to the CNO in all matters relating to the implementation and administration of all programs relating to COMSEC.

Within the COMSEC organization, commands are required to have a COMSEC visit at least once a year. These visits are held on an informal basis and provide on-the-spot advice and guidance to communications and noncommunications personnel who operate voice radio equipment or handle COMSEC material. Primary emphasis during these visits is placed upon identification and correction of common communications problems. Overriding attention is placed upon spotting insecure COMSEC practices and procedures and alerting personnel to communications vulnerabilities. These COMSEC visits are administered by the local Naval Security Group (NAVSECGRU). A NAVSECGRU may be a separate entity or may be part of a nearby NAVCOMMSTA. In any event, they perform the basic mission of COMNAVSECGRU in administering the COMSEC program first hand. Requests for these informal visits are sent directly to the appropriate NAVCOMMSTA or NAVSECGRU activity. Although COMSEC visits are only required once a year, it is good practice to schedule them more frequently.

NATIONAL SECURITY AGENCY (NSA)

Whereas COMNAVSECGRU acts as the principle agent for the CNO in most COMSEC matters, the National Security Agency (NSA) acts in behalf of the Secretary of Defense. The NSA is considered the government's executive agent in these matters, the primary difference between them and COMNAVSECGRU being that NSA acts in reference to all branches of the military involved in COMSEC matters.

Although the duties of NSA and COMNAVSECGRU parallel and overlap each other in many ways, the NSA clearly has a broader base of responsibility. To outline or list the many responsibilities would be lengthy and tedious. Suffice to say, the responsibilities of the NSA can be found in the applicable editions of KAG 1 and CMS 4. Of particular importance to communications personnel handling COMSEC material is the fact that NSA prescribes or approves all cryptographic systems and techniques used in any manner. This includes the doctrine and procedures governing their operation or use. It also includes any requests for change or modification to any cryptographic equipments or procedures. The NSA also produces or approves the production of all cryptomaterial used by the departments and agencies of the U.S. Government.

COMMUNICATION CENTER VISITOR'S LOG

Normally, entry to a secure communications space or facility will be limited to persons whose names appear on an officially promulgated entrance (or access) list. Persons seeking entry must be identified and shall be admitted only if their names appear on this list or if they have been specifically authorized admittance by a competent authority. Under no circumstances are personnel admitted to the facility merely because they are known to assigned communications personnel.

A register (or log) is used to record the arrival and departure of authorized personnel whose names do not appear on the access list. According to the effective edition of KAG 1, the following column headings are recommended for visitor's logs:

1. Date
2. Visitor's signature
3. Rank or Grade
4. Organization Represented
5. Purpose of visit
6. Signature of authority authorizing visit.
7. Time in and Time out.

PERSONAL SECURITY CENSORSHIP

Security violations result from bad personal habits, security indifference (apathy), occupational fatigue, or ignorance of established regulations. Whenever security violations occur in installations located in foreign countries, they become more serious due to an activity's greater vulnerability to hostile exploitation. With respect to COMSEC, much could be lost.

If a specific type of security violation is repeated, it is usually an indication of a bad habit. Bad security habits are usually the result of convenience, haste, or a developed pattern of carelessness in the daily handling of classified information and documents.

No one in the Navy is authorized to handle any classified material except that required in the performance of duty. All other persons are unauthorized, regardless of their grade, duties, or clearance.

If it is known, or even suspected, that classified material has been lost, or that unauthorized persons have had access to it, the material is said to be compromised. The seriousness of the compromise depends on the nature of the classified material and the extent to which the unauthorized person may divulge or make use of what he has learned.

A Radioman, or for that matter any person in the Navy, should report any security violation or compromise to his immediate superior, or any other person in authority. Failure to promptly report any and all cases may further the damage done with the material in the hands of hostile forces. There is no way of knowing how many violations have actually occurred, but were not reported, such as, leaving a classified document on the top of a desk overnight, leaving a safe open overnight or unattended, or discussing classified information over the telephone using so-called "double talk". It is for this reason that security training programs are administered, and a need exists for conscientious effort on the part of everyone. Security should be second nature insofar as the practice of personal habits are concerned. However, second nature does not mean "without thinking". It behooves all of us to take security seriously and practice sound security habits in the interest of naval operations and our national security overall.

CHAPTER 11

BASIC MESSAGE FORMAT

There are a wide number of message formats used in telecommunications, depending upon the method or mode of operation. For example, AUTODIN procedures and formats differ from those of AUTOVON and AUTOSEVOCOM. There are also basic differences between formatting and procedures involving Radiotelephone and manual Teleprinter communications. However, even though we have many types and modes of communications, the basic naval message has a central starting point. With few exceptions, military messages sent via telecommunications are arranged according to a basic format.

The basic message format is divided into three distinct parts:

1. Heading
2. Text
3. Ending

Within the heading, text, and ending are sixteen format lines. Each format line corresponds to a particular type of subject matter and places the contents of the basic message in a standard sequential order. Referring to table 11-1, we can see which format lines make up the three major parts of a basic message. It should be noted that format lines are only a method of placing the contents of a message in a standard sequential order; they bear no relationship to the number of handwritten or typed lines contained in each format line. For example, format line 4 may be used for relaying instructions, but these instructions may total ten lines on a typewritten message.

HEADING

Whereas the text of a message might contain the bulk of the typewritten lines in a naval message, the majority of the format lines are contained in the heading (format lines 1 through 10). The heading of a message is considered a message "part" and its associated lines are called "format lines." In addition to these, we also have message "components." There are a total of six components in a naval message, four of which are contained in the heading, and they are placed in a simple, logical order for clarity. The four components that comprise the heading are the:

1. Beginning procedure
2. Preamble
3. Address
4. Prefix

Table 11-2 shows the message heading, associated components, and their format lines.

Beginning Procedure

The beginning procedure component contains format lines 1 through 4. As there are different methods of transmission, the basic construction of the beginning procedure will vary. For example, when communicating via TTY, you would be using plain language address designators and TTY "routing indicators." When communicating via radiotelephone, you would be using spoken calls that correspond to the stations you are in communications with.

Format line 1 normally contains handling instructions and is used only in TTY relay and automatic digital networks. Format line 1 will be discussed in greater detail in chapter 13 (Manual Teletypewriter Procedure).

Format line 2 contains the called station(s) and any necessary exempted stations.

Format line 3 contains the identification of the calling station. The calling station will precede its calling designation with the prosign "DE" (which means "from"), or with the spoken words "this is," depending upon the method

Table 11-1. — Basic message format

Basic Message Part	Format Lines Contained	General Format-Line Content
HEADING	1	Used only in TTY
	2	Station(s) called, & exempted station(s).
	3	Prosign "DE" (or from) & calling station
	4	Instructions, e.g.; "T" (relay).
	5	Precedence and DTG
	6	Prosign "FM" (the originator of his message is) & originator.
	7	Prosign "TO" & action addressees.
	8	Prosign "INFO" & the information addressees.
	9	Prosign "XMT", & the exempted addressees.
	10	Accounting symbol, group-count, or "SVC" (service).
Separation	11	Prosign "BT" (Break)
TEXT		
	12	Basic idea of Originator.
Separation	13	Prosign "BT" (Break)
ENDING		
	14	Time-group (where appropriate).
	15	Final instructions, (e.g., Prosign "B" (more to follow).
	16	Ending sign, (e.g., "K" or "AR".

of communication being used. For example, if you are operating a radiotelephone circuit, your voice call sign is "Scott Key," and you want to communicate with a station whose voice call sign is "Knox Polk," you would say:

"Knox Polk	(Format line 2)
This is Scott Key"	(Format line 3)

and then continue to the next part of your transmission.

Format line 4, when used, contains transmission instructions. Transmission instructions normally tell the called station (format line 2) what to do or what action to take with reference to the handling or forwarding of the message. For example, the operating prosign "T" means: "Transmit this message to all addressees or to the addressee designations immediately following." If TTY or CW procedures are used, the prosign "T" would be written as is. However, in radiotelephone procedure, the spoken words "Relay To" are used instead. To expound on

Table 11-2.—Heading and components

Part	Component	Format Line
H	Beginning procedure	1
		2
E		
		3
A		4
	Preamble	5
D		
		6
I	Address	7
		8
N		
		9
G	Prefix	10

the example already used, your transmission could be:

"Knox Polk"	(Format line 2)
This is Scott Key	(Format line 3)
Relay to Abe Lincoln"	(Format line 4)

Then you would continue to the next part of your transmission. Bear in mind, however, that format line 4 could contain any one of a number of operating signals or prosigns that tell the called station what particular action to take with the received message. Prosigns are letters or combinations of letters that convey frequently sent orders or instructions in a standard form. Prosigns are covered later in this chapter.

Remember, the construction of this component varies according to the type of transmission media used. Instructions for message preparation in the primary media are contained in chapters 13, 14, and 15. Explicit and exact instructions for the preparation of this component for each of the transmission media are contained in the appropriate procedure publications (ACPs, NTPs, and JANAPs).

Preamble Component

Format line 5 contains the entire preamble component. Although there are three elements in the preamble, it is noted primarily as that part of the message containing the precedence and date-time group (including month and year, abbreviated).

The first element of the preamble is the precedence, indicated by the appropriate prosign. For example: Z, O, P, or R, as assigned by the originator.

The second element, the date-time group (DTG), appears as a six-digit number suffixed by the letter "Z" to indicate Greenwich Mean Time. The abbreviation for the month and year follows the date-time group. For example, the DTG of "O 121314Z JUL 76" indicates that the message is an "Immediate" (Prosign "O") and was originated on the 12th day, 13th hour, 14th minute Greenwich Mean Time in the month of July, in the year 1976.

The third and last element of format line 5, the message instructions, is used to express specific handling or delivery instructions desired by the communication center of the originator. These instructions are in the form of operating signals. Do not confuse this line with format line 4, which contains transmission instructions for the called station. The message instructions contained in format line 5 are not necessarily for the called station alone; they may pertain to any and all stations who handle the message. It should also be noted that format line 5 contains "execute" instructions when the "executive" method of communications is used. Executive method communications are covered in detail in ACP 124 (Radiotelegraph Procedures).

Address Component

The address component uses format lines 6, 7, 8, and 9 when the requirement exists. In other words, format lines 6 and 7 may be used, but no requirement may exist to use the rest of the format lines in this component (format lines 8 and 9). The lines correspond to originator, action addressee(s), information addressee(s), and exempted addressee(s). (See table 11-1.)

Format line 6 is the originator element. It is identified by the originator prosign "FM" (meaning "from") and contains the designation of the originating station.

Format line 7 is the action element. It is identified by the action prosign "TO" and contains the designation(s) of the action addressee(s).

Format line 8 is the information element and is designated by the prosign "INFO." It contains the designation(s) of the addressees who receive the message for information purposes only.

Format line 9 is the exempted element. It is identified by the prosign "XMT" and contains the designation(s) of the exempted addressee(s). For example, the action element may be a collective call sign that encompasses many stations. The originator of the message may want all but two of the stations in the collective call sign to receive the message. Therefore, the originator would place the names of the two stations to be exempted from receiving the message in format line 9.

An entire address might look something like the following:

FM	SCOTT KEY	(Format line 6)
TO	KNOX POLK	(Format line 7)
INFO	ABE LINCOLN PATRICK HENRY	(Format line 8)
XMT	THEODORE ROOSEVELT GEORGE WASHINGTON	(Format line 9)

Addressee designations in the address component may be call signs, address groups, plain language designators, or a combination of routing indicators and plain language designators, depending on the method of transmission.

Prefix Component

Format line 10 is called the prefix component and contains either the message group count or accounting information.

The accounting information is a combination of letters called an "accounting symbol." An accounting symbol indicates the agency of financial responsibility whenever a message is commercially refiled or whenever the message is one that is originated by an agency of the DOD and destined for a non-DOD agency. For example, a message indicating that the Navy has financial responsibility would contain the word "NAVY" in format line 10.

The group count appears as the prosign "GR" followed by a number. The number indicates the number of words in the text. For example, a text containing 15 words would contain the prosign GR15 in format line 10. A numerical group count is required for all coded group messages. Whenever an accounting symbol is used, either the group count must be used or the prosign "GRNC" (Groups Not Counted) must be included as part of format line 10. For detailed information on the usage of different accounting symbols as part of the prefix component, consult NTP 9 (Commercial Communications Instructions).

Separation

Format lines 11 and 13 are the separation sign "$\overline{\text{BT}}$," meaning "break." Its purpose is to provide a distinct separation between the heading and the text and between the text and the ending. Remember, the separation is not considered a message part or component, but it is considered an essential format line.

TEXT

The text is that part of the message which contains the thought or idea that the drafter desires to communicate. Remember, regardless of the number of lines written or typed by the drafter, the text uses only one format line: Format line 12.

In drafting the text for transmission, brevity is desirable through the proper choice of words and good writing technique. However, brevity must never be achieved at the expense of accuracy. Uncommon phrases and modes of expression can render the meaning of a message ambiguous or obscure.

The text must be worded so that it expresses unmistakably the thought to be conveyed. All abbreviations must be limited to those meanings which are self-evident, or those which are recognizable by virtue of long established use. The following is a discussion of some of the more important requirements concerning the text of a message.

Classification Line

The classification line is the first line of the text and immediately follows the "$\overline{\text{BT}}$" that separates the heading and text. It indicates the message classification, and when applicable, special handling markings, code or flag words, and the Standard Subject Identification Code (SSIC).

For U.S. use, the three classification designators are CONFIDENTIAL, SECRET, and TOP SECRET. The acronyms FOUO (For Official Use Only) and EFTO (Encrypt For Transmission Only) are not classification designators, yet they are used with the designation UNCLAS in the classification line. The same applies to the terms "Restricted Data" and "Formerly Restricted Data" in that they are used with classification designators. The proper spelling and spacing of classification designators are displayed in figure 11-1. Information regarding the criteria and handling of FOUO and EFTO messages can be found in NTP 3.

Special Handling Markings

Certain types of messages require special handling in addition to that provided by the security classification. These special markings are placed in the classification line immediately following the classification. Some of the more common special handling markings that you will see are:

1. SPECAT (Special Category)
2. LIMDIS (Limited Distribution)
3. PERSONAL FOR
4. NAVY EYES ONLY

For example, there are two types of SPECAT messages: Those associated with code words or projects and those which are delivered only to a named individual. Therefore, a Secret message whose subject matter deals with information regarding a special project entitled "TACAMO" would have a classification line reading: "SECRET SPECAT TACAMO."

UNCLAS

UNCLAS E F T O

UNCLAS E F T O FOUO

C O N F I D E N T I A L

S E C R E T

T O P S E C R E T

76.142

Figure 11-1.—Classification spelling and spacing.

The other type of SPECAT message, "Exclusive For," is used whenever sensitive information is to be passed only to a particular individual. The classification line would then contain the name of that individual. For example, a Secret message destined exclusively for Admiral D. R. Smith would read:

"SECRET SPECAT EXCLUSIVE FOR ADM D. R. SMITH"

LIMDIS messages require limited distribution within the addressed activity. Only classified messages qualify for the special handling marking LIMDIS. However, the classification is still assigned according to subject matter. Therefore, the classification line would read: "SECRET LIMDIS."

PERSONAL FOR messages are limited to the named recipient (who may direct further distribution). In PERSONAL FOR messages, the classification line always shows the name or title of the intended recipient and may show the name or title of the originator. For example:

"UNCLAS PERSONAL FOR RADM R. L. ROARKE."

or

"UNCLAS PERSONAL FOR RADM R. L. ROARKE FROM ADM D. R. SMITH."

It should be noted that PERSONAL FOR messages are used by the Navy only and are not used in messages addressed to other than Navy commands.

The designation "NAVY EYES ONLY" is applied to classified messages to preclude handling by personnel of the other military services. For example:

"CONFIDENTIAL NAVY EYES ONLY."

The Standard Subject Identification Code (SSIC) is always the last element of the classification line and identifies the subject matter of the message. The SSIC is required on all messages, with few exceptions, and those messages without them are normally returned to the drafter.

The SSIC is preceded and followed by two slash signs. For example: "UNCLAS EFTO FOUO //N58416//." The SSIC always contains 5 numbers corresponding to particular subject matter, preceded by the letter "N." Detailed information concerning requirements for classification line markings are contained in NTP 3.

Passing Instructions

Passing instructions in a message are typed consecutively, beginning at the left-hand margin, one line below the classification line. For example, a message from CINCLANTFLT NORFOLK VA to COMSUBLANT NORFOLK VA, ultimately intended for a particular person or office known by the originator might read "COMSUBLANT FOR MR FRISCH" in the passing instructions. A passing instruction first cites the addressed command's short title, then the office code or individual's name.

Subject Line

The subject line of a message begins at the left-hand margin immediately following the classification line (or the passing instructions, when used). The subject line is not necessary, though desirable. It may be omitted in tactical messages (1) when it would classify an otherwise unclassified message, (2) when it would noticeably increase the length of a short message, or (3) when the subject is readily apparent in the first line of the text.

Reference Line(s)

Reference lines are used in order to avoid repeating lengthy quotations or references within the text of a message. The primary requirements for reference lines are that they be clear and sufficiently specific. References are lettered consecutively, one beneath the other. For example, the following references would be listed as shown, immediately following the subject line:

A. COMSUBGRU SIX 092042Z SEP 76
B. COMSUBLANT NORFOLK VA 121156Z DEC 76.

Thereafter, whenever mention is made of those references, they would be referred to as "Ref (A)" or "Ref (B)," as applicable.

Indenting

The classification, passing instructions, subject, and reference lines always begin at the left-hand margin. When necessary (usually for graphic clarity), textual material may be indented as many as twenty spaces.

When the text proper is begun, (after the reference line(s), if used), the message may contain several subjects, or several aspects of one subject. For this reason, textual material is divided into paragraphs and sub-paragraphs which are numbered and lettered consecutively. It should be noted that single paragraph messages need not be numbered. Figure 11-2 is an example of the usage of the classification, subject, and reference lines, with proper indentation. Notice that the subject line is marked with the proper classification, as are the paragraphs and sub-paragraphs. This is in accordance with OPNAVINST 5510.1, that requires that all electrically transmitted messages be paragraph marked for classification.

Restricted Data
Paragraph Markings

Some types of information are defined as being "Restricted" or "Formerly Restricted" data. This means that the information falls into the several categories of nuclear-oriented subject matter in accordance with the Atomic Energy Act of 1954.

When such information appears in the text of a message, it is necessary to add the markings "RD" or "FRD" in addition to classification markings. For example, if a paragraph of a message is classified Secret and is also Restricted Data, the paragraph would be marked "SRD." If it were Confidential as well as being Formerly Restricted Data, it would be marked "CFRD," etc.

Punctuation

Within the text of a message, punctuation is used when essential for clarity. Authorized abbreviations are used whenever the method of transmission will not permit the usage of the punctuation mark as is. Punctuation marks are transmitted exactly as drafted, otherwise communications personnel must substitute authorized abbreviations for the punctuation mark. A complete list of authorized punctuation marks and their abbreviated equivalents is contained in NTP 3.

```
P       151000Z JUL 76

FM      NAVSUBSCOL NEW LONDON CT

TO      NAVSUBTRACENLANT CHARLESTON SC

INFO    NAVSHIPYD PUGET SOUND BREMERTON WA

XMT     COMSUBRON FOURTEEN
        COMSUBRON SIXTEEN

BT

UNCLAS PERSONAL FOR RMCM R.M. RILEY //N05723//

FORM 20 ANSWER SHEETS (U)

A.  YOUR 150800Z JUL 76
B.  NETPDCINST 2020.20A PARA 20 CHG 1
1.  (U)  MOUNT WHITNEY FORM 20 ANSWER
SHEETS NOW AVAILABLE AS REQ REF (A).
2.  (U)  REF (B) CITES AUTH FOR LOWER
PAY GRADE EXAMINATIONS IAW SC EDSPEC.

BT
```

76.143

Figure 11-2.—Example of usage of classification, subject, and reference lines.

ENDING

The ending, the third and last part of a message, is another changeable portion. It contains the ending procedure and uses format lines 14, 15, and 16.

Format line 14 is the time group element. (See table 11-1.) When used, this element contains the time group, expressed in hours and minutes, plus the zone suffix. For example, "0830R" indicates the time in hours and minutes in the time zone Romeo.

Format line 15 is called the final instructions. The communications operator may use this line to correct transmission errors, indicate a pause, execute a message, or indicate more traffic for a specific station by the use of prosigns, operating signals, and station designators, as required. Remember, format lines 14 and 15 may not be used at all, depending upon the communication situation.

Format line 16 is called the ending sign. For voice transmissions, this is the proword "OVER" or "OUT." For CW or TTY transmissions, it would be the prosigns "K" or "AR." This format line is used merely to indicate the end of transmission.

MESSAGE USER RESPONSIBILITIES

There are certain responsibilities associated with the origination of a message. These responsibilities are separate and distinct and have to do with the following three persons:

1. Drafter

2. Releaser

3. Originator

Occasionally the responsibilities may overlap, especially if there is one person serving in a dual capacity. For example, the communications officer may draft and release a message in certain situations, thus making him both drafter and releaser.

The drafter is the person who actually composes the message. In accordance with NTP 3, it is the drafter who is responsible for:

1. Proper addressing
2. Clear, concise composition
3. Selection of precedence
4. Ensuring proper format
5. Ensuring proper classification
6. Ensuring application of proper downgrading and declassification instructions

The releaser is a properly designated individual who is authorized to release a message for transmission in the name of the command or activity. The releasing individual ensures that the drafter has complied with the requirements contained in NTP 3. In addition to validating the contents of the message, the releaser's signature affirms compliance with message drafting instructions. It is the releaser's signature that authorizes the message for transmission.

The originator is the authority (command or activity) in whose name the message is sent. The originator is assumed to be the commanding officer of the command or activity. Most often, the originator and the releaser are one and the same. Also, in some cases, the drafter, releaser, and originator can all be one and the same. For example, if the commanding officer drafted a message for transmission, he would be the drafter as well as the releasing authority and the activity in whose name the message is sent.

After a message has been properly released, it is delivered to the Telecommunications Center (TCC) for transmission. The date-time group is normally assigned here. Proper transmission, receipting, and filing procedures are accomplished by the communications personnel.

An important point to remember regarding the date-time group is that it is assigned for identification purposes only. It is not used for any computation of message processing time.

Precedence

The message drafter indicates the desired writer-to-reader delivery time through the assignment of a message precedence. Although the drafter determines the precedence, the releaser may either confirm or change it. Precedence is assigned according to urgency, not according to the importance of the subject matter of the text. For example, an administrative message may be assigned a higher precedence than a message containing Top Secret information. This would be due to the necessity for faster action upon the administrative message, whereas, the Top Secret message may not require fast response or action at all. The following is a list of the various precedence categories, their indicators, and basic definitions:

1. Routine (R) - is assigned to all types of traffic which justify electrical transmission but which are not of sufficient urgency to require a higher precedence.

2. Priority (P) - is reserved for messages which furnish essential information for the conduct of operations in progress. This is the highest precedence normally authorized for administrative messages.

3. Immediate (O) - is reserved for messages relating to situations which gravely affect the national forces or populace and which require immediate delivery to addressees.

4. Flash (Z) - is reserved for initial enemy contact reports or operational combat messages of extreme urgency; message brevity is mandatory.

In addition to the four major precedence categories, an Emergency Command Precedence (ECP) is used within the AUTODIN system. This ECP is identified by the precedence prosign "Y" and is limited to designated emergency action command and control messages.

Speed of Service Objectives

There are many factors which may affect writer-to-reader delivery time. These factors include types of facilities, types of systems used, traffic volume, relay requirements, message length, number of addressees, circuit conditions, etc. The speed of service objectives listed in figure 11-3 provide general guidance. However, it should be obvious to all Radiomen that message traffic is handled as rapidly as possible, consistent with reliability and security.

Precedence	Prosign	Speed of Service Objective
Flash	Z	As fast as possible with an objective of less than 10 minutes
Immediate	0	30 minutes
Priority	P	3 hours
Routine	R	6 hours

76.144

Figure 11-3.—Speed of service objectives.

CLASSES OF MESSAGES

Messages are placed in different classes in order to aid administration and accounting, especially where tolls and charges are involved. In general, we have five classes of messages: A, B, C, D, and E. Of the five classes, A, B, and C are government messages. Classes D and E are non-government (or private) messages.

The largest volume of message traffic handled by the Navy is Class A. This particular class message is one which is originated by Department of Defense activities and destined for DOD activities. This includes the Coast Guard when it is operating as part of the Navy.

Class B traffic is an official message originated by and destined for U.S. Government agencies other than the Department of Defense. When the Coast Guard is not considered a part of the Navy, it is considered as falling into the Class B category.

Class C messages consist of broadcast traffic in special forms, available to ships of all nationalities—for example, hydrographic data, weather, time signals, etc.

Class D messages are private messages for which the Navy collects tolls. This group includes the radiotelegrams and press messages sent by correspondents aboard ship.

Class E messages are personal messages to and from naval personnel, handled free of charge over naval circuits. Charges are collected from the sender only when commercial communication companies, such as Western Union, handle the message over part of its route. The Class E message privilege is used primarily to enhance morale. It provides a means of communication on urgent personal matters for personnel at sea and is unavailable between points on shore within the United States.

ADDRESSEES

Most messages have at least one addressee responsible for taking action on the contents and for originating any necessary reply. Addressees with an official concern in the subject of the message but who do not have primary responsibility for acting on it, receive the message for information. Although an information addressee is usually only concerned indirectly with a message, occasionally they must take action of some kind within their own commands. Some messages have only information addressees.

Messages may be divided into types, according to the way they are addressed, as follows:

1. Single-Address - A message having only one addressee, which may be either for action or information.
2. Multiple-Address - A message which has two or more addressees and is of such a nature that the drafter considers that each addressee must be informed of all other recipients.
3. Book - A message destined for two or more addressees but is of such a nature that the drafter considers it unnecessary that each addressee be informed of any other addressees.
4. General Message - A message designed to meet recurring requirements for the dissemination of information to a wide, predetermined, standard distribution.

230

Naturally, a single-address message is the simplest of the four and requires no explanation. A multiple-address message will bear all of the original addressees, both action and information, that the originator included.

Book messages are normally routed according to each addressee's relay station, with all unnecessary addressees deleted from the face of the message prior to being sent to the addressee(s) served by that particular relay station.

General messages are normally titled (e.g., ALCOM, NAVOP, JAFPUB, etc.), with the title indicating distribution. The title serves as the address designator.

Plaindress and Abbreviated Plaindress

A plaindress message is one in which the originator and addressee designations appear externally in the address component. The plaindress message is the most commonly used on naval circuits. Basically, the plaindress format contains all of the components of the basic message except that the group count may be omitted. Referring back to table 11-1, we see that this is format line 10 of the basic message. However, remember that anytime the text is encrypted or uses an accounting symbol to denote financial responsibility, the group count prosign (GR) must be included in the prefix component.

The following is an example of how a plaindress message might look if you were operating a ship-to-ship teletype circuit:

Example 1:

Format Line	Transmission
2 & 3	NRMR DE NDRS
4	T
5	R 270907Z JUL 76
6	FM USS LINCOLN
7	TO USS POLK
8	INFO USS KEY
11	BT
12	TEXT (PLAIN LANGUAGE)
13	BT

Note that the text is in plain language and no accounting data is required; so the prefix component is omitted.

Where operational requirements are of such a nature that speed of handling is of prime importance, the plaindress message may be abbreviated. Abbreviated plaindress format is used very extensively in voice communications, although it may be used in other formats as well.

In the abbreviated plaindress form, the initial call serves as the address. In other words, if your initial call-up is "ROOSEVELT THIS IS WASHINGTON" on a radiotelephone circuit, format lines 6, 7, 8, and 9 need not appear in the heading. However, remember that in order to have the call serve as the address, you must be in direct communication with the station or stations for which the message is intended, thereby eliminating the need for format lines 6 through 9. Also included in the elements that may be omitted in abbreviated plaindress procedure are the precedence, date, date-time group, and group count. The following is an example of an abbreviated plaindress message as it might appear on a radiotelephone net:

Example 2:

Format Line	Transmission
2 & 3	ROOSEVELT THIS IS WASHINGTON
11	BREAK
12	TEXT (PLAIN LANGUAGE)
13	BREAK
16	OVER

In example 2, the originator (WASHINGTON) is in direct communications with the addressee (ROOSEVELT). Therefore, the call serves as the address. Notice that there is no date-time group. In radiotelephone circuit operation, it is normal procedure to omit the date-time group if there is not an expectation of any further reference to the message. If the originator feels that there may be further reference to a message sent in this manner, a date-time group or a four-digit time group may be added (Format line 5).

Codress

A codress message is one sent in encrypted form. Being encrypted, it always contains a numerical group count in the prefix. A codress message contains all the components of the basic message format except the address component. The entire address component is included within the encrypted text. This makes the codress message a valuable security measure which the originator may employ when it is desirable to conceal the identity of the addressees. In so doing, we deny the enemy the luxury of being able to make inferences from originator/addressee traffic patterns that would otherwise be revealed by the use of an external address. Detailed instructions for the preparation and transmission of codress messages are contained in current cryptographic regulations and in NTP 4.

CALL SIGNS

Call signs are letters, letter-number combinations, or one or more pronounceable words, used chiefly to identify communication activities and for establishing and maintaining communications. They are applicable in both military and civil communications and are of several categories, with some belonging to more than one category.

International Call Signs

International call signs are assigned to radio stations of all countries, both civilian and military, afloat and ashore. These call signs are assigned according to international agreement. The United States has the first half of the "A" block (A through ALZ) and all of the "K," "W," and "N" blocks. They are assigned as follows:

A Block	Army and Air Force
K and W Blocks	Commercial and Private Stations, Merchant Ships
N Block	Navy, Marine Corps, Coast Guard

Naval shore communication stations have three-letter N calls. For example, NAM. . . . .NAVCOMMSTA, Norfolk. Exceptions to the three-letter N calls for naval shore communication stations are U.S. NAVRADSTA Thurso, Scotland ("GXH"), NAVCOMMSTA Morocco ("CNL"), and NAVCOMMSTA Spain ("AOK").

Call signs for fixed and land radio stations are listed in ACP 100 and U.S. Supplement 1 thereto. International call signs assigned to U.S. naval vessels are four-letter N calls and are used for all nonmilitary international communications. For example, NJFK. . . . . .USS John F. Kennedy (CVA 67).

International call signs for USN, USMC, and USCG aircraft are composed of the N, NM, or NC, respectively, followed by the last four digits of the serial or systems command number of the aircraft.

Military Call Signs

Most ships of the Allied Nations are assigned military call signs in addition to their international call signs. When used to address messages, military call signs are always encrypted. Both international and military call signs are listed in ACP 113.

Collective Call Signs

Collective call signs pertain to two or more facilities, commands, or units. For example, NIMK. . . . .All U.S. submarines copying this broadcast.

Voice Call Signs

Voice call signs are words or combinations of words, such as "TRIDENT" or "CARD BAY," and are limited to radiotelephone communications. Those call signs located in the Joint Voice Call Sign Book (JANAP 119) and in the Allied Tactical Voice Call Sign Book (ACP 119) are only for tactical circuits. On ship-shore administrative circuits, phonetically spelled international call signs are given as ship's voice calls. Under certain conditions, ship's names are used as voice call signs on local harbor circuits.

Net Call Signs

Net call signs represent all stations within a net. (A net is a group of stations in direct communication with each other on a common channel). For example, OVERWORK. . . . .All U.S. Navy stations on this radiotelephone circuit.

ADDRESS GROUPS

Address groups are four-letter groups assigned to represent a command, activity, or unit. In military communications, they can be used in the same manner as call signs to establish and maintain communications. Generally speaking, call signs and address groups are used by the Navy in exactly the same way. Address groups never start with the letter "N"; hence, they are easily distinguishable from naval radio call signs. You have learned the difference between call signs for naval ships and shore radio stations. Address groups, however, follow no distinctive pattern, and the arrangement of the four letters that constitute them conveys no significance whatsoever.

Afloat commands (except individual ships) and shore-based commands or activities not served by their own communication facilities are assigned address groups. For example,

1. Senior commands and commanders ashore, such as the secretaries of defense and of the Navy.
2. Navy bureaus, systems commands, and district commandants.
3. Elements of the shore establishment having a need for direct addressing and receipt of message traffic (such as weather centrals).

Among other uses, address groups facilitate delivery of message traffic when a communication center serves so many activities that its own call sign is insufficient to identify the addressee. Address groups are contained in ACP 100 and its U.S. Supplement. Like call signs, address groups are divided into types:

1. Individual Activity
2. Collective
3. Conjunctive
4. Geographic
5. Address Indicating
6. Special Operating Groups

Individual Activity Address Groups

Individual activity address groups are representative of a single command or unit, either afloat or ashore. For example,

DTCI - COMPHIBLANT
SSMW - CHIEF OF NAVAL OPERATIONS (CNO)

Collective Address Groups

Collective address groups represent two or more commands or activities. Included in this group are the commander and his subordinate commanders. For example,

JTJF - COMSUBRON 14
YQRV - COMSUBRON 16

Conjunctive and Geographic Address Groups

Conjunctive and geographic address groups are mentioned together because they are interrelated in their usage.

Conjunctive address groups have incomplete meanings and must have other address groups added to them in order to denote a specific command or location. It is for this reason that conjunctive address groups are used only with one or more address groups. For example, the conjunctive address group "XZKW" means "all ships present at ___________." In order to complete the meaning, it must be followed by a geographic address group.

Geographic address groups are the equivalent of geographical locations or areas. They are always preceded by conjunctive address groups. For example, the address group: "DEXL" could represent Newport, R.I.. Therefore, all ships present at Newport would be addressed: "XZKW DEXL".

Address Indicating Groups

Address indicating groups (AIGs) represent a specific set of action and/or information addressees. The purpose of AIGs is to increase the speed of traffic handling. They shorten the message address by providing a single address group to represent a large number of addressees, thus eliminating individual designators for each address used in the heading. For example, let's assume that a hypothetical AIG (AIG 31) is used to address SUBMISS/SUBSUNK message traffic by COMSUBLANT to 30 action addressees and 35 information addressees. Since a single AIG (AIG 31) is used, 65 call signs and address groups are eliminated from the heading of the message.

AIGs are normally created whenever particular types of message traffic become repetitive enough and are addressed to enough of the same addressees to warrant it. Among such message traffic are:

1. Alerts, air defense warnings, emergency actions, etc.
2. Destructive weather warnings (hurricanes, typhoons, etc.).
3. Notice to Airmen (NOTAMS).
4. Intelligence summaries.
5. Movement reports.

It should be noted that an AIG will not be established for groups of addressees numbering less than five. Requests for the establishment of an AIG are sent to COMNAVTELCOM. A complete listing of AIGs by number, cognizant authority, and purpose is contained in NTP 3. A partial listing of AIGs, along with specific action and information addressees, may be found in ACP 100 U.S. Supplement 1.

Special Operating Groups

Special Operating Groups (SOGs) are four-letter groups that are identical in appearance to address groups. However, SOGs are not used unless specifically authorized by CNO. A list of SOGs, together with their associated meanings, is in ACP 100.

Routing Indicators

Routing indicators identify stations in a communications relay network and are comprised of from four to seven letters. It is easy to distinguish routing indicators from call signs and address groups; routing indicators always begin with the letter "R."

PLAIN LANGUAGE ADDRESS DIRECTORY (PLAD)

The plain language address directory (PLAD) lists the plain language address (PLA) to be used in message addressing for Navy, Marine Corps, and Coast Guard activities. The PLAD is included as a supplement to NTP 3 and is arranged into three basic sections:

1. Section One—contains plain language addresses. Within this section are several chapters listing commands alphabetically by long title and short title, separating the Navy, Marine Corps, and Coast Guard commands. There are also separate chapters listing U. S. Navy and U. S. Coast Guard ships.

2. Section Two—contains an alphabetical sorted list of authorized collective address designators (CAD) and their cognizant authorities. A collective address designator (CAD) is a single address group which represents a predetermined set of five or more activities linked by an operational or administrative chain of command. The cognizant authority is the commander of the above mentioned activities linked together. An example of a CAD is "ALL SSBN PAC" with COMSUBPAC as the cognizant authority.

3. Section Three—contains the instructions for the use of Address Indicating Groups (AIG) previously discussed.

Plain Language Addresses

The PLAs listed in the PLAD are the only designators authorized for use in message addressing by Navy, Marine Corps, and Coast Guard activities. Deviations from PLAD spelling are not allowed nor are deviations in spacing and formatting. This is due to automated processing systems being keyed to PLAD entries, and these systems will reject any message which contains other than PLAD entries. The use of punctuation or any other extraneous characters is also prohibited. Office codes are considered to be a form of punctuation, and their use is prohibited.

Plain Language Address Spelling

NTP 3 contains all of the accepted long and short titles to be used when a message is addressed. Also contained in NTP 3 are the state and county abbreviations that are authorized when a naval message is addressed. The following basic rules are excerpted from NTP 3 because of the ambiguity that normally exists in these areas:

1. The use of any element of punctuation is prohibited.

2. Numbers from ten through nineteen are written as such. For example: COMSUBRON SIXTEEN instead of COMSUBRON ONE SIX. All other numbers are spelled out digit for digit, for example: AIG SIX FOUR, CTG SIX NINE PT ONE.

3. Cities and towns are not abbreviated. States and countries are abbreviated in accordance with the abbreviations found in NTP 3. Those countries not found in NTP 3 will be spelled out.

4. Whenever the words "SAINT," "MOUNT," "POINT," and "FORT" are used as a part of a geographic location, they will be abbreviated as "ST," "MT," "PT," and "FT," respectively. When these same four words are used as a part of an activity short title, they will not be abbreviated.

5. When used as part of a task organization, the word "POINT" will be abbreviated. For example: "TG SIX ZERO PT TWO."

Use of the
Word "ADMIN"

The word "ADMIN" is normally used in message traffic between a flag rank commander and his staff or in messages originated by the staff and destined for other activities. For example, whenever the flag rank commander is temporarily detached from the headquarters location, the From line of a message addressed to the staff would show the commander's complete plain language address, and the To line would show the word "ADMIN" followed by the commander's complete plain language address, as shown in the following example:

FM COMSUBLANT NORFOLK VA
TO ADMIN COMSUBLANT NORFOLK VA

A commander's staff, during his absence, may use the proword "ADMIN" in the From line of messages originated by the staff and destined to the commander or other activities, as shown in the following example:

FM ADMIN COMSUBLANT NORFOLK VA
TO COMSUBLANT

or

FM ADMIN COMSUBLANT NORFOLK VA
TO CNO WASHINGTON DC

READDRESSING A MESSAGE

Occasionally, your command will want to readdress a message to other ships or activities that were not included in the original address. Whenever this is done, the following rules apply:

1. All format lines preceding line 5 (precedence and DTG) of the original message heading are deleted.

2. No alteration can be made to the original message from the precedence to the end of the text.

3. A "supplementary" heading is inserted in front of the original heading.

4. The precedence indicated in the supplementary heading pertains to the supplementary address only.

5. The DTG of the original message is used for purposes of reference, reply, and filing.

For example, assume that on receipt of the following plaindress message, NRMR readdresses it to NEMB for information. Here is the original message received from NDRS:

NRMR DE NDRS

P - 121025Z AUG 76

FM NDRS

TO NRMR

GR32

BT

TEXT

BT

Station NRMR adds his supplementary heading and transmits the following to NEMB:

NEMB DE NRMR

P - 121037Z AUG 76

FM NRMR

TO NEMB

P - 121025Z AUG 76

FM NDRS

TO NRMR

GR32

BT

TEXT

BT

Notice that everything preceding line 5 of the original message to NRMR has been deleted prior to readdressal.

CANCELLING MESSAGES

Only the originator may cancel a message. All message directives are automatically cancelled ninety days following the release date except when:

1. the text provides for an earlier cancellation,

2. a subsequent message extends the cancellation date, or

3. the directive is reissued by the originator in standard format within ninety days of the release date.

Whenever a message contains time sensitive information which becomes obsolete by a certain time, it will be appended by the statement: "THIS MESSAGE IS CANCELLED AT (TIME/DATE)"

PROSIGNS

Procedure signs, or prosigns, are letters or combinations of letters that convey frequently sent orders or instructions in a simple, standard format. Although some prosigns may seem to be abbreviations of their assigned meanings, prosigns are never referred to as abbreviations. The following is a complete list of authorized prosigns. Whether you are operating communications equipment on a circuit aboard ship or ashore, it is helpful to have as complete a command of these prosigns as possible. A recommended method of learning them is to prepare a number of cards with the prosign on the front and its meaning on the back, and use them for self-drill.

1. Precedence Prosigns:

Z	FLASH.
O	IMMEDIATE.
P	PRIORITY.
R	ROUTINE.

2. Prosigns that identify portions of a transmission:

AA	All after.
AB	All before.
WA	Word after.
WB	Word before.

3. Ending prosigns:

K	Go ahead; or, this is the end of my transmission to you and a response is invited.
AR	End of transmission; no receipt required.

4. Pause prosigns:

AS	I must pause for a few seconds.
AS AR	I must pause longer than a few seconds; will call you back.

5. Separation prosigns:

BT	Break. (Separates text of message from heading and ending.)
II (Written in messages as a short dash)	Separative sign. (Used to separate certain elements of message headings. Not to be used as punctuation to represent a hyphen or dash in message texts.)

6. Prosigns always followed by one or more call signs and/or address groups:

DE	From (in call).
FM	Originator's sign.
TO	The addressee designations immediately following are addressed for action.
INFO	The addressee designations immediately following are addressed for information.
XMT	Exempt. (Used to exempt addressees from a collective call or address.)

7. Prosigns used in transmission instructions of a message:

T	Transmit this message to all addressees or to the addressee designations immediately following.
G	Repeat this entire transmission back to me exactly as received.
F	Do not answer.

8. Group count prosigns:

GR plus numerals	Group count.
GRNC	The groups in this message have not been counted.

9. Prosigns used with the executive method:

$\overline{\text{IX}}$	Action on the message or signal that follows is to be carried out upon receipt of "Execute."
$\overline{\text{IX}}$ Plus 5-second dash	"Execute"—carry out the purpose of the message or signal to which this applies.

10. General:

$\overline{\text{AA}}$	Unknown station.
B	More to follow.
C	Correct.
EEEEEEEE	Error. (At least 8 Es.)
EEEEEEEE $\overline{\text{AR}}$	This transmission is in error. Disregard it.
$\overline{\text{HM}}$ $\overline{\text{HM}}$ $\overline{\text{HM}}$	Emergency silence sign.
$\overline{\text{IMI}}$	Repeat.
$\overline{\text{INT}}$	Interrogative.
J	Verify with originator and repeat.
NR	Station serial number.
R	I received your last transmission satisfactorily.

OPERATING SIGNALS

Like prosigns, operating signals provide communication operators with a brief signal that conveys a much longer expression and would require greater circuit time if sent in its longer form. However, unlike prosigns, operating signals are comprised of three letters and begin with either "Q" or "Z." These operating signals are used in every form of electrical telecommunication except radiotelephone. In radiotelephone, "PROWORDS" are used instead. An exception to this rule is made when a message containing an operating signal is relayed by radiotelephone; then the operator will transmit the group phonetically.

ACP 131 contains a listing of all Q and Z signals that are authorized for use by naval communications operators. You should study ACP 131 carefully so that you, as a communications operator, are familiar with those operating signals that may be used when communicating with civil stations, Allied Nations, other naval ships, etc. Generally speaking, "Q" signals are for use between Civil Aviation units or civil international units; whereas, "Z" signals are primarily for use between Allied military units. Naturally, all Q and Z signals may be used between U.S. naval units because all naval units should hold ACP 131 as a basic part of their shipboard communication publication allowance.

Use of Operating Signals

Operating signals may be used in one of two ways. As a question or as a statement. Placing the prosign "$\overline{\text{INT}}$" before an operating signal places it in the form of a question. For example, let's assume that USS ABRAHAM LINCOLN (SSBN 602) is having trouble communicating with USS JAMES K. POLK (SSBN 645) and inquires as to whether POLK is being interfered with. (See example 1.)

Example 1: LINCOLN asks:

NNBD DE NOKB $\overline{\text{INT}}$ QRM K

POLK answers:

NOKB DE NNBD QRM K

In the preceding example, NOKB asked NNBD if he is being interfered with by using the operating signals $\overline{\text{INT}}$ QRM. QRM, when preceded by $\overline{\text{INT}}$, means "Are you being interfered with?" $\overline{\text{INT}}$ means "Interrogative." NNBD answered by saying that he is being interfered with. The use of the operating signal QRM by itself means "I am being interfered with."

Some signals must be accompanied by a numerical suffix that completes, amplifies, or varies the basic meaning. For example, an operator may want to know what the strength of the transmitted signals is at the receiving station. In order to find out, the following transmission could be sent between LINCOLN and POLK:

Example 2:

NNBD DE NOKB $\overline{\text{INT}}$ QSA K
POLK answers:
NOKB DE NNBD QSA4 K

In example 2, NOKB sent "$\overline{\text{INT}}$ QSA," which means: "What is the strength of my signals?" NNBD answered: "QSA4," which means: "The strength of your signals is very good."

In communication with non-military stations, the prosign "$\overline{\text{IMI}}$" after the Q signal is used instead of $\overline{\text{INT}}$ before the Q signal to give an interrogatory meaning.

Unless they are encrypted, operating signals possess no security and must be regarded as the equivalent of plain language. Operating signals sent on approved wire circuits that are properly cleared are not considered compromising. Also, operating signals sent on approved on-line circuits are considered to have been encrypted.

MESSAGE CATEGORIES

Naval communications enable naval commanders to make their wills known and, as such, is the voice of command. Naval messages speak for and with the authority of the commander who originated them.

All official messages, whether classified or not, contain privileged information. No person is entitled to knowledge or possession of classified or unclassified communications solely by virtue of grade, position, office, or clearance; a need to know must exist. The contents of all other personal and commercial messages handled by naval communications are revealed only to the person(s) addressed and the personnel who must handle them at the naval telecommunications center (NTCC).

Commercial messages concerning death, serious illness, injury, etc., will be processed with adequate precautions in order to prevent their contents being disclosed to the addressee in a rash manner. Normally, local amplifying instructions clarify these particular methods.

It is important to remember that there are many types and categories of naval messages. Each type or category receives different treatment with reference to internal routing and distribution. However, there are certain categories of message traffic that are common to most Radiomen. These message categories are usually similar in format and are recognizable on a repeating basis. When not similar in format, they are usually recognizable by content. Although space precludes a total discussion of all the various message categories, the following is a discussion of the more common ones.

General Messages

General messages provide a standard distribution to a large group of addressees and are identified by a repetitive short title (e.g., ALNAV, JAFPUB, etc.). The types of general messages, from whom they originate, and their distribution, are found in Appendix A of NWP 4.

All commands to whom general messages are distributed are considered to be action addressees; however, it is command responsibility to determine what action, if any, need be taken upon receipt of a general message. Those general messages which are of sufficient operational importance to warrant immediate delivery to forces afloat are sent on fleet broadcasts; those which are not are handled via the "Basegram" system (discussed later).

Although general messages have a wide, standardized distribution, every command receiving a particular one may not have any action to take. However, all commands are required to keep a continuous numerical file of all general messages that they are on the distribution list for and receive. Consequently, the general message files contain every general message received during the calendar year, in numerical order. The general message files are separate from all other files and are subdivided according to identifying title or type. The following example shows what would be a typical heading on a commonly received type of general message:

P 170805Z AUG 78
FM SECNAV WASHINGTON DC
TO ALNAV
BT
UNCLAS //N01600//
ALNAV 08/78

In this example, the line immediately prior to the subject line is utilized to inform the reader that this is the eighth ALNAV message of 1978. The title "ALNAV" indicates this message is intended for wide distribution throughout the Navy.

General messages are cancelled in the following ways:

1. The first general message of a calendar year lists those messages of the previous year(s) (by number) which remain in effect. If necessary, interim cancellation messages may be sent at other times during the year.
2. An individual general message may include its own cancellation date within the text. Additionally, a subsequent message of the same series may cancel a message.
3. General messages which do not have a yearly cancellation message and are not assigned particular cancellation dates are automatically cancelled after 90 days. Normally, messages of this type are included in the Navy Directive System (NDS).

Basegrams

General messages that are not of sufficient operational importance to warrant immediate delivery to forces afloat guarding the fleet broadcast are called "Basegrams." The purpose of the basegram system is to reduce the volume of message traffic transmitted via the fleet broadcasts in order to keep the broadcast available for vital traffic.

Afloat commands can obtain the missing basegrams that were not sent via the fleet broadcast from basegram authorities. A basegram authority is a shore commander who is responsible for providing plain-text copies of basegrams to afloat forces operating within his area of responsibility. The basegram authority maintains a stock of plain-text copies of general messages applicable to forces afloat for pickup upon their arrival in port.

The originators of general messages may assign the designation BASEGRAM when appropriate. The word BASEGRAM is the first word of the text immediately following the security classification. Those general messages designated as basegrams will carry the operating signal "ZFP" (basegram) in the message instructions.

American Red Cross Messages

The American Red Cross may use the facilities of naval communications, free of charge, for sending and receiving emergency and administrative traffic as prescribed in U.S. Navy Regulations. However, in each case this privilege is subject to the approval of the commanding officer who may refuse to extend this service if it would prove detrimental to naval administration or operations.

Red Cross messages are handled as Class B traffic and are normally in plain text. Most Red Cross messages are assigned a precedence of ROUTINE; however, critically important ones may be assigned up to IMMEDIATE over naval circuits. When the Red Cross is assisted during a civilian disaster, message traffic may be given equal precedence with military traffic over naval circuits at the discretion of the senior officer present at the scene of the disaster.

As a rule, Red Cross traffic is not accepted if it cannot be handled entirely over naval circuits. The exception to this rule is whenever emergencies or disasters involving relief occur.

Minimize Messages

Military telecommunications systems tend to become overloaded during an emergency. Naturally, it becomes necessary to reduce unnecessary traffic volume in order to clear user circuits for essential traffic. This reduction in traffic is accomplished by promulgation (usually by message) of the word "MINIMIZE," which has the following meaning: "It is now mandatory that normal message and telephone traffic be reduced drastically in order that vital messages connected with the situation indicated shall not be delayed."

A message ordering minimize consists of the word "Minimize" followed by the area affected (scope), reason, and duration of the minimize condition (when known). Messages imposing minimize must be brought to the immediate attention of the Communications LPO and Communications Officer.

During minimize conditions, messages should not be held for delivery after minimize is lifted. Maximum effort should be made to utilize airmail letters and speedletters as a means of delivering traffic, observing security precautions.

CNO, Fleet Commanders in Chief, and area coordinators are authorized to impose minimize conditions on users of naval communications systems. Subordinate commanders may impose minimize over elements of their commands only with prior permission from one of those three.

During minimize conditions, FLASH and IMMEDIATE traffic should be kept to no more than 100 and 200 words, respectively. Message releasers are also kept to a minimum and are specifically designated. NWP 4 contains information pertaining to the types of normal, environmental, and supply traffic that may be sent over normal channels and circuits during minimize.

Proforma Messages

Proforma messages are messages whose subject matter and sequence of textual content are preset and connot be changed by the originator. Figure 11-4 is an example of a Proforma message that may be used to recommend either an urgent or safety change to NWP 11(B). These are the only two subject areas for which this particular message can be used. Notice that the textual sequence of information follows a preset format. Whenever an originator prepares a message dealing with either of the two subjects shown, the text must follow the sequence shown, including paragraph and sub-paragraph markings.

Proforma messages enhance the standardization of repetitive message subject matter and ensure less ambiguity in those areas. They encompass a large variety of messages, such as Publication Change Recommendations, Hydrographic Information, Movement Reports, etc. They reduce the chance of error through interpretation, a very important area, especially in movement reporting where misinterpreted information could mean an at-sea collision or result in communications personnel copying the wrong broadcast.

Many proforma messages are computer-generated. A number of automated systems, such as the World Wide Military Command and Control System (WWMCS) and those employed in Tactical Support Centers (TSC), are capable of automatically generating messages with varying degrees of required message formats. These types of messages are normally destined for a communications central processor designed to accommodate and route such traffic, or they may simply be processed directly into communications channels.

Movement Reports

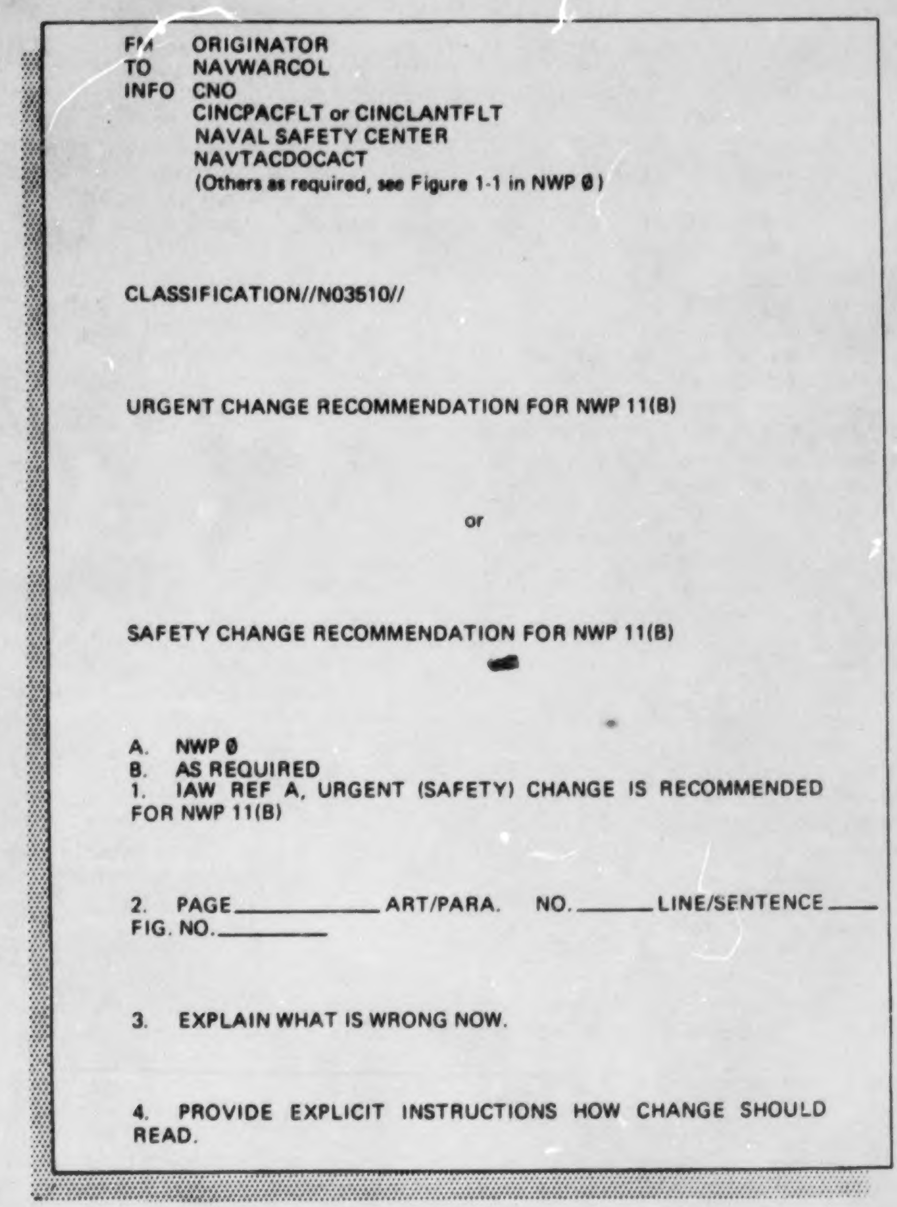
Hundreds of naval fleet units are deployed at any one time. For command and administrative purposes, it is necessary to have up-to-the-hour information on their location. The dissemination of movement report information is the function of the movement report system.

The controlling agency of the entire movement report system is the Movement Report Control Center at Washington DC (MRCC WASHDC). For reporting purposes, the world is divided into zones, and each zone is controlled by a movement report center (MRC). The zones are further subdivided into areas. Each area is controlled by a movement report office (MRO). A movement report center may receive information on movements all over the world, but movement report offices have information on movements in their area of responsibility only.

Prior to deployment, a ship sends a movement report message which states time of departure, destination, route, speed of advance, and any other information required. The message enters the system through the MRO or MRC controlling the area in which the ship is located. The MRO or MRC then disseminates the information to military and civilian activities with an official interest in the location or movements of the vessel. Such activities include supply centers, fleet post offices, fleet broadcast stations and customs authorities. These movement reports are prepared in accordance with NWP 7.

"Q" Messages

Allied Nations have navigational warning systems that are used primarily during wartime. Certain portions of these systems are used to promulgate classified information of a sensitive



FM ORIGINATOR
TO NAVWARCOL
INFO CNO
CINCPACFLT or CINCLANTFLT
NAVAL SAFETY CENTER
NAVTACDOCACT
(Others as required, see Figure 1-1 in NWP 0)

CLASSIFICATION//N03510//

URGENT CHANGE RECOMMENDATION FOR NWP 11(B)

or

SAFETY CHANGE RECOMMENDATION FOR NWP 11(B)

A. NWP 0
B. AS REQUIRED
1. IAW REF A, URGENT (SAFETY) CHANGE IS RECOMMENDED FOR NWP 11(B)

2. PAGE__________ ART/PARA. NO.______ LINE/SENTENCE____
FIG. NO.________

3. EXPLAIN WHAT IS WRONG NOW.

4. PROVIDE EXPLICIT INSTRUCTIONS HOW CHANGE SHOULD READ.

76.135

Figure 11-4. — Example of Proforma message.

nature that the enemy would have trouble obtaining on his own, such as information concerning minefields and channels through them. These classified portions of Allied navigational warning systems are known as "Q" messages. Information concerning the "Q" system is found in AHP 1. Occasionally, the "Q" system is used in peacetime fleet exercises at the discretion of the officer conducting the exercise (OCE).

Service Messages

Service messages are short, concise messages between communications personnel. For communication personnel, such messages have the authority of an official communication and are to be accorded prompt attention. If action requested in a service message cannot be accomplished within a reasonable time, the station who originated the service should be so notified. Service messages are normally assigned a precedence the same as the message being serviced.

The number of topics that a service message may deal with are many, but you will find that most deal with such things as corrections, repetitions, broadcast re-runs, misrouted or missent messages, etc. Primary to remember is that a service message should be promptly dealt with and retained until all action regarding it has been completed. It is also good practice to either attach the service to the message proper when it is filed or mark the file copy with the DTG of the service(s).

Requests for information through service messages should be kept to a minimum consistent with reliable communications to avoid overloading circuits and to protect security. Remember, careful attention to detail and the employment of proper operating techniques by communication and crypto personnel will do much to reduce the number of service messages required.

Service messages are normally prepared in abbreviated plaindress format and may be assigned sequential reference numbers. The service message number will immediately follow the abbreviation "SVC" in the message text. If used, sequential service reference numbers may continue throughout the calendar year. When you are replying to a service message received with a reference number, the text of the reply should make reference to the number. For example,

UNCLAS SVC ZUI SVC 0245
RUEDCSA1234 1921600

The preceding example is a service message inviting attention (ZUI) to a previous service message with a reference number of 0245. Occasionally, you will see the abbreviation COSIR in a service message text, which means: "Cite Our Service In Reply."

The texts of all service messages begin with an indication of security as the first word of the text followed by the abbreviation SVC, unless the service message is one requiring special handling. For example,

UNCLAS SVC

or,

SECRET SPECAT SIOP ESI SVC

If a service message quotes the textual content of a classified message or refers to the classified message in a manner which reveals textual content, the service message must be assigned the same classification as the classified message being serviced.

Tracer Messages

Tracer messages are sent to determine the reason for inordinate delay in the delivery or non-delivery of a message previously sent. Tracer action continues on a station-to-station basis until the cause of delay has been determined. Upon receipt of tracers, each station should examine its records for the time of transmission of the message being traced. This information is compiled and transmitted with the tracer action to the preceding station and to the station which originated the tracer. Any station which caused the delay or non-delivery will cite the reason and a resume of corrective action in the report.

Tracer action requests will be initiated as soon as the discrepancy is discovered but no later than 30 days from the original time of transmission. In-station records, files, logs, and tapes will be retained beyond the thirty (30) day limit if a tracer action is in progress prior to the expiration date. Detailed information concerning tracer action can be found in JANAP 128.

Termination Request Messages

Termination request messages are used to establish a circuit with another station on a limited or full-time basis, whichever is the desire of the commander making the request. A termination request message is sent to the NAVCAMS in whose area the ship is operating. If the ship has a requirement for a full-time termination, it will be assigned a routing indicator by the cognizant NAVCAMS. NTP 4 contains complete information pertaining to termination requests and their formats.

Communications Shift Messages

Communications shift messages are sent whenever you shift from one broadcast to another. The messages normally effect a shift to another broadcast starting at 0001Z. When broadcasts are shifted, an overlap period before and after the effective time is observed to ensure continuity of traffic.

Shift messages are sent to the NAVCAMS of the communications area or areas from which the old and the new broadcast originate. Shift messages are normally made necessary owing to operational considerations or changes in the deployment schedule of a ship. They are also made necessary when a command needs to effect a shift at a time other than that indicated by their movement report. Information regarding communications shift messages and their formats are contained in NTP 4.

JCS Emergency Action Messages

JCS Emergency Action Messages (EAMs) contain key instructions or information from high-level authority and have predetermined formats (proforma). Such messages are transmitted via various communications systems and normally carry FLASH precedence. They are vital messages of an extremely time-sensitive nature, and rapid processing is mandatory to obtain the fast reaction required by their content. Usage and handling procedures are of higher classification and have been promulgated by the JCS to those who have a need to know.

Submarine Check Reports

Submarine Check Reports are used to ensure safety accountability of submarines. They are assigned an automatic precedence of IMMEDIATE and can be identified by the word "CHECK" as the first word of the text. (See figure 11-5.) If received for handling and further relay, these types of messages should be given expeditious treatment. Delays and non-deliveries can result in the initiation of SUBMISS/SUBSUNK procedures. The "TWO FOUR" contained in the text of the message in figure 11-5 indicates that the submarine is on a 24-hour check schedule.

Message Cancellations

In naval communications, many types of messages have self-contained cancellation dates. Others, such as those in the Navy Directive System, are automatically cancelled after 90 days unless specifically extended. In any and all cases, it must be remembered that only the originator has the authority to cancel a message. Unless the process is self-contained, this is accomplished by drafting and releasing an entirely separate message that refers to the message to be cancelled.

SECTION I, SUMMARY

Section I has been an introduction to basic message format, procedures, and types. It is by no means all-inclusive in these areas of naval communications. However, the information presented in these basic areas, coupled with the

```
O 190810Z AUG 76

FM    USS FRANCIS SCOTT KEY

TO    COMSUBRON SIXTEEN

INFO  COMSUBGRU SIX
      COMSUBLANT NORFOLK VA

BT

UNCLAS

CHECK TWO FOUR SUBMARINE FRANCIS SCOTT KEY.

BT
```

76.145

Figure 11-5.—Example of typical submarine check report.

more detailed procedures and parallel information contained in JANAP 128, NTP 3, and NTP 4, form the basis of a sound, working knowledge of format and procedures. Section II of this chapter will present the formatting and basic procedures relating to Optical Character Reader (OCR) Messageform DD 173.

SECTION II, OPTICAL CHARACTER READER MESSAGE FORM DD 173

One of the principal objectives of the automation program in Navy telecommunications is the elimination of routine, human functions which are most prone to error. Many message processing functions have been automated through the introduction of electronic devices which are programmed to perform operations formerly performed by communications personnel. One such device is the Optical Character Reader (OCR) which rapidly and accurately transcribes a typewritten outgoing message into a language compatible with computer processing. The two major processing systems which employ OCR equipment are the Local Digital Message Exchange (LDMX) and the Naval Communications Processing and Routing System (NAVCOMPARS). Messages to be processed through these systems by OCR must be typed on Joint Messageform DD-173, using a typewriter with an OCRE "A" character set.

GENERAL INSTRUCTIONS

Joint Messageform DD-173 is available through the Naval Supply System in two colors, red or light blue. The color a particular activity must use is determined by the type of OCR equipment used by the serving telecommunications center. Locally reproduced copies of DD-173 cannot be used as they cannot be processed by the OCR.

Special equipment, as discussed in SECNAV Instruction 10460.9B, is required for typing DD-173. It is essential that the typewriters and carbon-type ribbons specified in this instruction be used. Also, it is essential that typewriters be well maintained to ensure production of dark, clear characters. In addition, only certain letters, numbers, and abstract symbols can be used in typing DD-173. (See figure 11-6.)

Letters and Numbers

ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789

Symbols

.	Period	Colon	:
,	Comma	Dollar Sign	$
?	Question Mark	Apostrophe	'
/	Slant	Semi-Colon	;
{	Left Parenthesis	Ampersand	&
}	Right Parenthesis	Quotation Mark	"
-	Minus, Hyphen or Dash	Hook	⑀
■	Blob	Christmas Tree	⑁

76.146

Figure 11-6.—Authorized character set for DD-173 messageform.

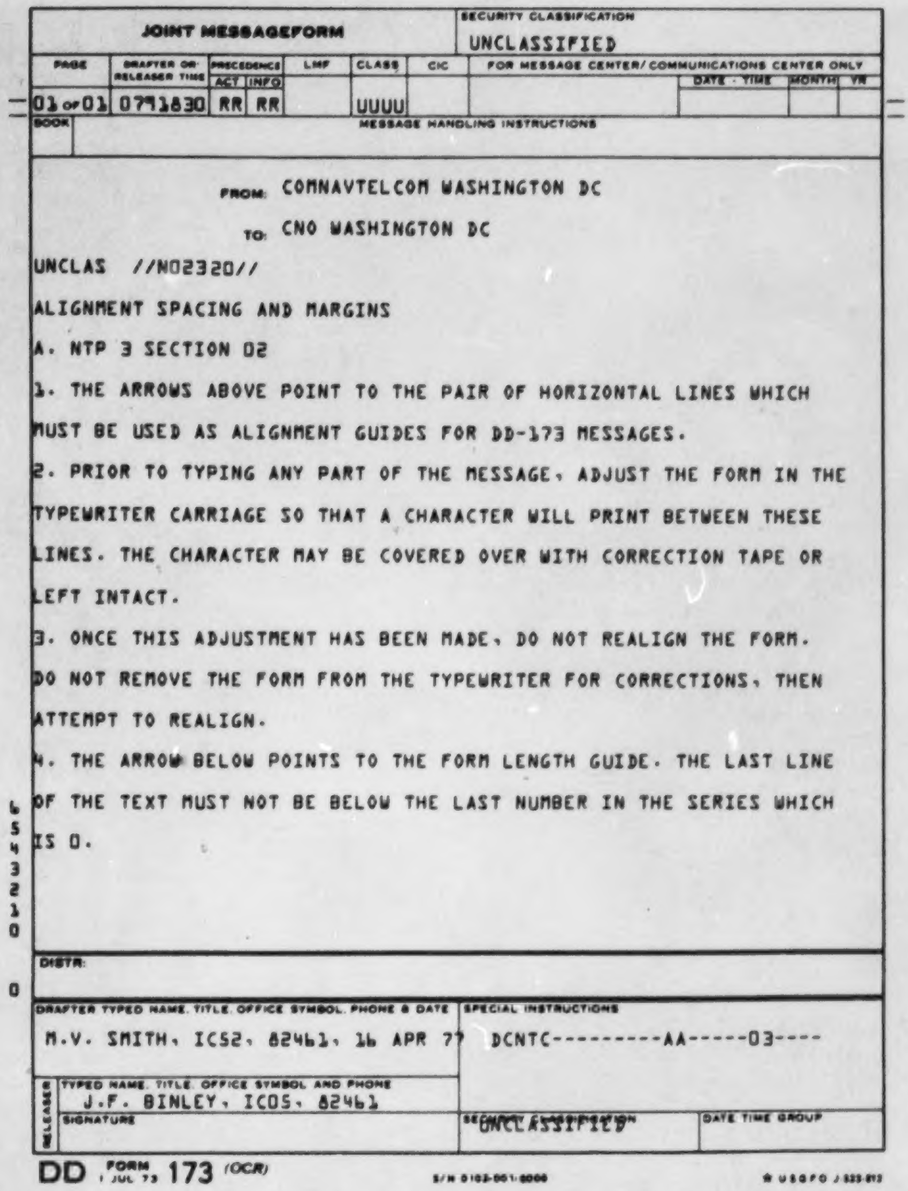
DD-173 Alignment

DD-173 messages enter the telecommunications system through an OCR which is programmed to process certain groups of characters at specific locations on the messageform. If the form is misaligned before typing, or if the spacing or margins do not conform to programmed requirements, then the OCR will not find the correct characters at the designated locations and the message will not be entered into the telecommunications system.

There are two extended horizontal lines in the upper left and right hand margins of DD-173 which must be used as guides to obtain proper alignment. (See figure 11-7.) Prior to typing any part of the message, adjust the form in the typewriter carriage so that a typed character will print between these lines. Using self-adhesive correction tape, cover over the typed characters used to align the form prior to forwarding for release. Once the alignment has been made, do not realign the form. Do not remove the form from the typewriter for corrections then attempt to realign.

Spacing and Margins

All typing entries in the header lines, address component, text, and distribution block must be double spaced. Typing entries below the distribution block (below the second heavy line shown in figure 11-7) may be single spaced.



JOINT MESSAGEFORM

SECURITY CLASSIFICATION
UNCLASSIFIED

PAGE	DRAFTER OR RELEASER TIME	PRECEDENCE ACT	PRECEDENCE INFO	LMF	CLASS	CIC	FOR MESSAGE CENTER/COMMUNICATIONS CENTER ONLY	DATE - TIME	MONTH	YR
01 of 01	0791830	RR	RR		UUUU					

BOOK
MESSAGE HANDLING INSTRUCTIONS

FROM: COMNAVTELCOM WASHINGTON DC

TO: CNO WASHINGTON DC

UNCLAS //N02320//

ALIGNMENT SPACING AND MARGINS

A. NTP 3 SECTION 02

1. THE ARROWS ABOVE POINT TO THE PAIR OF HORIZONTAL LINES WHICH MUST BE USED AS ALIGNMENT GUIDES FOR DD-173 MESSAGES.

2. PRIOR TO TYPING ANY PART OF THE MESSAGE, ADJUST THE FORM IN THE TYPEWRITER CARRIAGE SO THAT A CHARACTER WILL PRINT BETWEEN THESE LINES. THE CHARACTER MAY BE COVERED OVER WITH CORRECTION TAPE OR LEFT INTACT.

3. ONCE THIS ADJUSTMENT HAS BEEN MADE, DO NOT REALIGN THE FORM. DO NOT REMOVE THE FORM FROM THE TYPEWRITER FOR CORRECTIONS, THEN ATTEMPT TO REALIGN.

4. THE ARROW BELOW POINTS TO THE FORM LENGTH GUIDE. THE LAST LINE OF THE TEXT MUST NOT BE BELOW THE LAST NUMBER IN THE SERIES WHICH IS 0.

6
5
4
3
2
1
0

DISTR:

0

DRAFTER TYPED NAME, TITLE, OFFICE SYMBOL, PHONE & DATE
M.V. SMITH, ICS2, 82461, 16 APR 77

SPECIAL INSTRUCTIONS
DCNTC---------AA-----03----

RELEASER TYPED NAME, TITLE, OFFICE SYMBOL AND PHONE
J.F. BINLEY, ICOS, 82461

SIGNATURE

SECURITY CLASSIFICATION
"UNCLASSIFIED"

DATE TIME GROUP

DD FORM 1 JUL 73 173 (OCR) S/N 0102-001-8000 ★ USGPO

76.136

Figure 11-7.—Proper alignment, spacing and margins.

For margin, the typewriter paper guide should be set at 0, the left margin at 6, and the right margin at 75. These margin settings allow 69 spaces or characters per line maximum, and this limit must not be exceeded.

At the lower left-hand side of the form, there is a series of numbers which act as the form length guide. (See figure 11-7.) The last line of the text must not be below the last number in the series, which is 0.

Typing Errors

Typing errors cannot be erased. If a typing error is made in the headerlines, it can be corrected using self-adhesive correction tape or the correcting function of the IBM Selectric

II typewriter. If a typing error is made on any other part of the messageform, it can be corrected using either of the two methods already mentioned, or it can be struck over with the abstract symbol "blob" (see figure 11-6), and the correct character then typed in the following space.

HEADERLINES

Headerlines are located at the top of DD-173 Messageform. The following is a brief discussion of their basic usage.

Page Block

The Page block contains four numeric characters divided into two sets. A single page message would contain "01 of 01" in the Page block as shown in figure 11-8. Multiple page messages are numbered sequentially according to an estimate of the total page length. For example, the first page of an estimated three-page message would be numbered "01 of 03," the second page "02 of 03," etc. If the page length is estimated incorrectly, it is not necessary to renumber the entire message. In such a case, it is necessary only to make the actual number of pages tally with the total typed on the last two pages. For example, if a previous page is numbered "03 of 05" and page 04 is the actual last page, the previous page must be renumbered "03 of 04" and the last page numbered "04 of 04." Other previous pages do not have to be changed. (See figure 11-8.)

Time Block

This block contains the Julian date and time the message was typed. The Julian Calendar sequentially numbers the days of the year beginning with 1 January, and each day is numbered consecutively thereafter, (i.e., 1 January is Julian 001 and 1 February is 032). Time is expressed in Greenwich Mean Time (Z). The entire block requires seven numeric characters. (See figure 11-8.)

Precedence Block

The precedence typed in the Action and Info blocks must each be two letter codes, as shown in figure 11-8. The precedence typed in the Info block cannot be higher than that typed in the Action block. If there are no information addressees, repeat the Action precedence in the Info block. The following is a listing of the acceptable two letter precedence codes:

Precedence	Two Letter Code
Emergency	YY
Flash	ZZ
Immediate	OO
Priority	PP
Routine	RR

Class Block

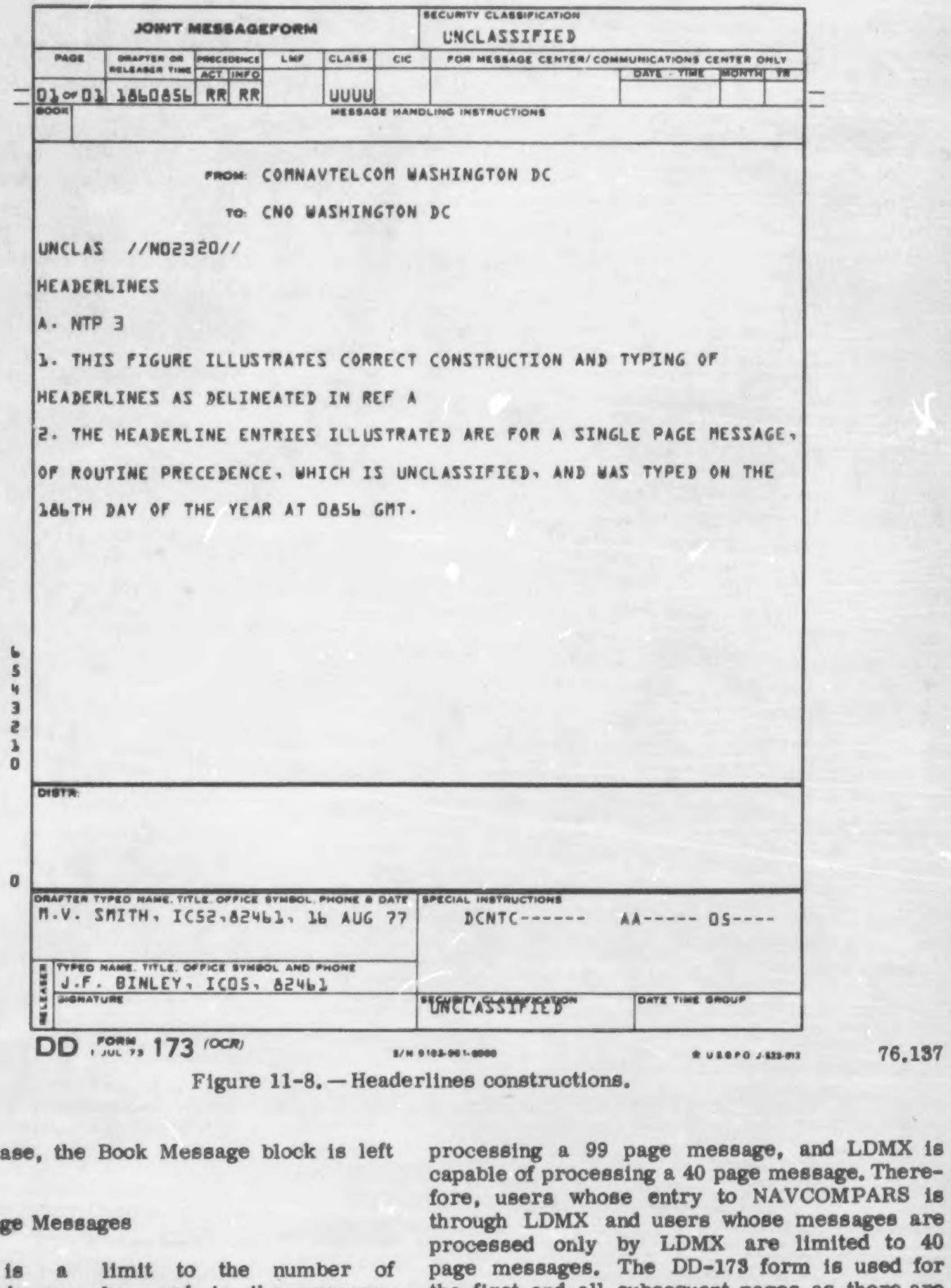
The entry in this block must be a four-character security redundancy code, as shown in figure 11-8. In the event of readdressal messages and retransmission requests, the security redundancy code of the readdressal or request must equal that of the original message. The following is a list of the four letter redundancy codes:

Classification	Four Letter Redundancy Code
Top Secret	TTTT
Secret	SSSS
Confidential	CCCC
Unclassified	UUUU
Unclassified EFTO	EEEE
Specat	AAAA

It should be noted that the Content Indicator Code block (CIC), LMF block, Date Time block, and Month and Year block are left blank. On the second and subsequent pages of a multiple page message, the Classification block is left blank.

Book Message Block

A book message is one which is destined for two or more addressees but is of such a nature that the originator considers that no addressee need or should be informed of the other addressee(s). To indicate that a message typed on DD-173 must be handled as a book message, the operating signal "ZYQ" is inserted in the Message Handling Instructions block. To indicate that a message may be handled as a book message but need not be, the operating signal "ZEX" is inserted in this block.



JOINT MESSAGEFORM

SECURITY CLASSIFICATION
UNCLASSIFIED

PAGE	DRAFTER OR RELEASER TIME	PRECEDENCE ACT	PRECEDENCE INFO	LMF	CLASS	CIC	FOR MESSAGE CENTER/COMMUNICATIONS CENTER ONLY	DAYS - TIME	MONTH	YR
01 OF 01	1860856	RR	RR		UUUU					

BOOK

MESSAGE HANDLING INSTRUCTIONS

FROM: COMNAVTELCOM WASHINGTON DC

TO: CNO WASHINGTON DC

UNCLAS //N02320//

HEADERLINES

A. NTP 3

1. THIS FIGURE ILLUSTRATES CORRECT CONSTRUCTION AND TYPING OF HEADERLINES AS DELINEATED IN REF A

2. THE HEADERLINE ENTRIES ILLUSTRATED ARE FOR A SINGLE PAGE MESSAGE, OF ROUTINE PRECEDENCE, WHICH IS UNCLASSIFIED, AND WAS TYPED ON THE 186TH DAY OF THE YEAR AT 0856 GMT.

6
5
4
3
2
1
0

DISTR:

0

DRAFTER TYPED NAME, TITLE, OFFICE SYMBOL, PHONE & DATE
M.V. SMITH, ICS2,82461, 16 AUG 77

SPECIAL INSTRUCTIONS
DCNTC------ AA----- OS----

RELEASER
TYPED NAME, TITLE, OFFICE SYMBOL AND PHONE
J.F. BINLEY, ICOS, 82461

SIGNATURE

SECURITY CLASSIFICATION
UNCLASSIFIED

DATE TIME GROUP

DD FORM 1 JUL 73 173 (OCR) S/N 0102-001-0000 ☆ U.S.G.P.O. [illegible] 76,137

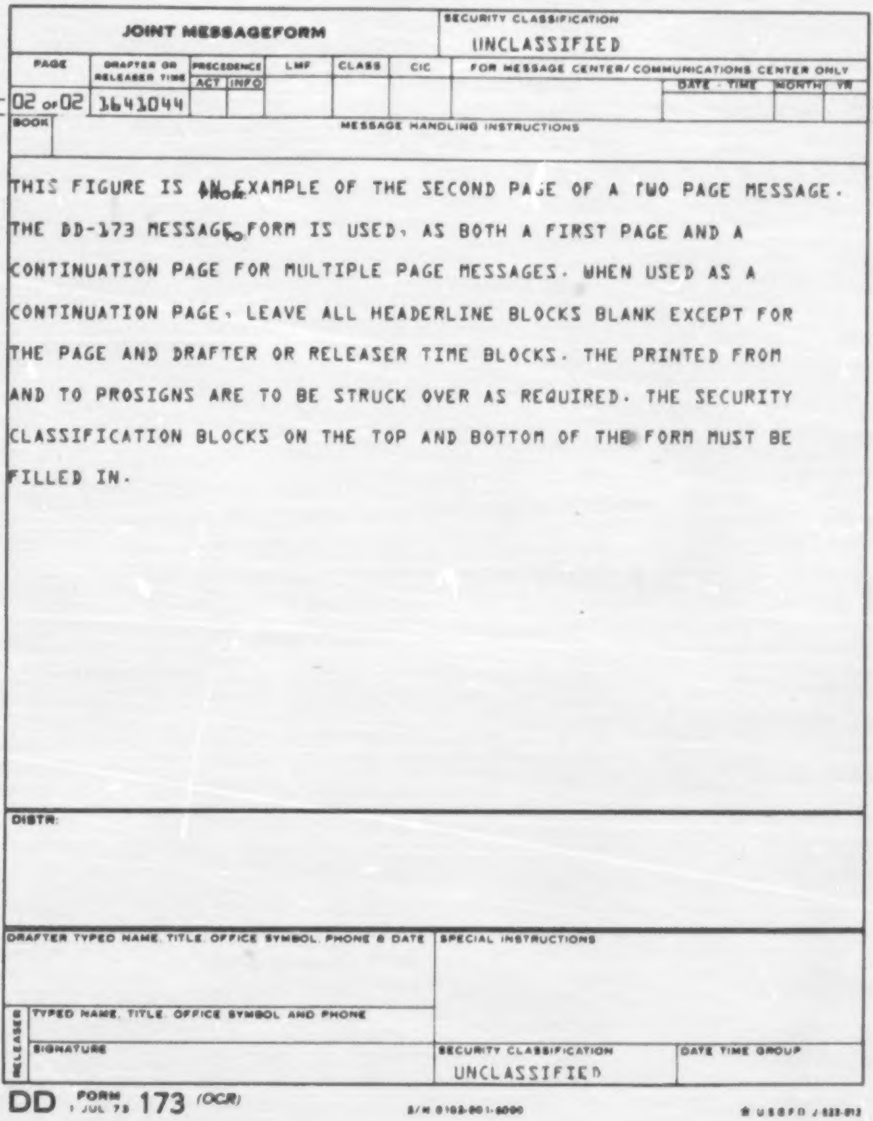
Figure 11-8.—Headerlines constructions.

In either case, the Book Message block is left blank.

Multiple Page Messages

There is a limit to the number of pages which can be used in the preparation of DD-173. NAVCOMPARS is capable of processing a 99 page message, and LDMX is capable of processing a 40 page message. Therefore, users whose entry to NAVCOMPARS is through LDMX and users whose messages are processed only by LDMX are limited to 40 page messages. The DD-173 form is used for the first and all subsequent pages as there are no "continuation" pages used to supplement the basic form. When the message exceedes the 99 or 40 page minimum, respectively, a new message must be originated.

Multiple page messages will result from two conditions: First, when the number of addressees exceeds the number that can be typed on one page (nineteen), and secondly, when the text exceeds the number of lines that can be typed on one page. For multiple page messages, on the second and all subsequent pages, only the Page, Time, and Classification blocks need be filled in on the header lines. (See figure 11-9.) The printed "FROM" and "TO" designations should be typed through. It should also be noted that multiple page messages are never stapled together. If it is necessary to



JOINT MESSAGEFORM

SECURITY CLASSIFICATION
UNCLASSIFIED

PAGE	DRAFTER OR RELEASER TIME	PRECEDENCE ACT	PRECEDENCE INFO	LMF	CLASS	CIC	FOR MESSAGE CENTER/COMMUNICATIONS CENTER ONLY	DATE - TIME	MONTH	YR
02 OF 02	1641044									

BOOK

MESSAGE HANDLING INSTRUCTIONS

THIS FIGURE IS AN EXAMPLE OF THE SECOND PAGE OF A TWO PAGE MESSAGE. THE DD-173 MESSAGE FORM IS USED, AS BOTH A FIRST PAGE AND A CONTINUATION PAGE FOR MULTIPLE PAGE MESSAGES. WHEN USED AS A CONTINUATION PAGE, LEAVE ALL HEADERLINE BLOCKS BLANK EXCEPT FOR THE PAGE AND DRAFTER OR RELEASER TIME BLOCKS. THE PRINTED FROM AND TO PROSIGNS ARE TO BE STRUCK OVER AS REQUIRED. THE SECURITY CLASSIFICATION BLOCKS ON THE TOP AND BOTTOM OF THE FORM MUST BE FILLED IN.

DISTR:

DRAFTER TYPED NAME, TITLE, OFFICE SYMBOL, PHONE & DATE

SPECIAL INSTRUCTIONS

RELEASER

TYPED NAME, TITLE, OFFICE SYMBOL AND PHONE

SIGNATURE

SECURITY CLASSIFICATION
UNCLASSIFIED

DATE TIME GROUP

DD FORM 1 JUL 73 173 (OCR)

S/N 0102-001-6000

☆ USGPO

76.138

Figure 11-9.—Example of the second page of a multiple-page message.

fasten them together prior to release or transmission, use a paperclip.

CONSTRUCTING THE ADDRESS

OCR-equipped, automated message processing systems route outgoing traffic based on a scan of the addressees in the address component. Because of this, it is necessary that the command short titles and geographic locations typed in the address component correspond exactly to the titles and locations stored in the processing system's memory. The phrase used to denote a command's short title and location together, used for message addressing, is "plain language address" (PLA). The supplement to NTP 3 contains the Plain Language Address Directory (PLAD). The PLAD is a listing of approved Navy and Marine Corps plain language addresses. Plain language addresses typed in the address component must conform to those contained in the PLAD. Do not add any characters or any form of punctuation.

From and To Lines

The originator's plain language address must begin at tab stop 26 and may not extend through tab stop 75. It must be remembered that you start the DD-173 at zero(0), and the "tab stops" referred to are merely the numbers on the numerical scale reading from left to right on your typewriter. The originator's PLA cannot exceed fifty characters or spaces. A continuation line cannot be used. (See figure 11-10.)

The action addressees' PLAs must begin at tab stop 26 and may extend to tab stop 75. (See figure 11-10.) Unlike the From line, continuation lines can be used for action, info, and exempt addressees when their PLAs are longer than fifty characters or spaces.

When using a continuation line, type the first fifty characters or spaces on the first line; then at tab stop 31 of the next double spaced line, type the remaining characters. This procedure can be repeated as many times as necessary. Do not use any form of punctuation to indicate that the PLA has been broken between two or more lines. Succeeding addressees begin at tab stop 26.

Info and Exempt Lines

The first information addressee must be preceded by the prosign INFO on the first double spaced line below the last action addressee. (See figure 11-10.) If there are no action addressees, type the first information addressee on the To line, preceded by the prosign "INFO." In both cases, the prosign begins at the tab stop 21 and is typed only once. All information addressees' plain language addresses (PLAs) begin at tab stop 26. If more than one line is required for an addressee's PLA, use the continuation procedure already discussed for action addressees.

To exempt addressees, type the prosign "XMT" on the first, double-spaced line below the last addressee, starting at tab stop 21. Then, starting at tab stop 26, list the full plain language addresses of the exempted addressees, as shown in figure 11-10. If more than one line is required for the PLAs, the continuation line procedure is as that used for action and information addresses.

Transmission By Other Means

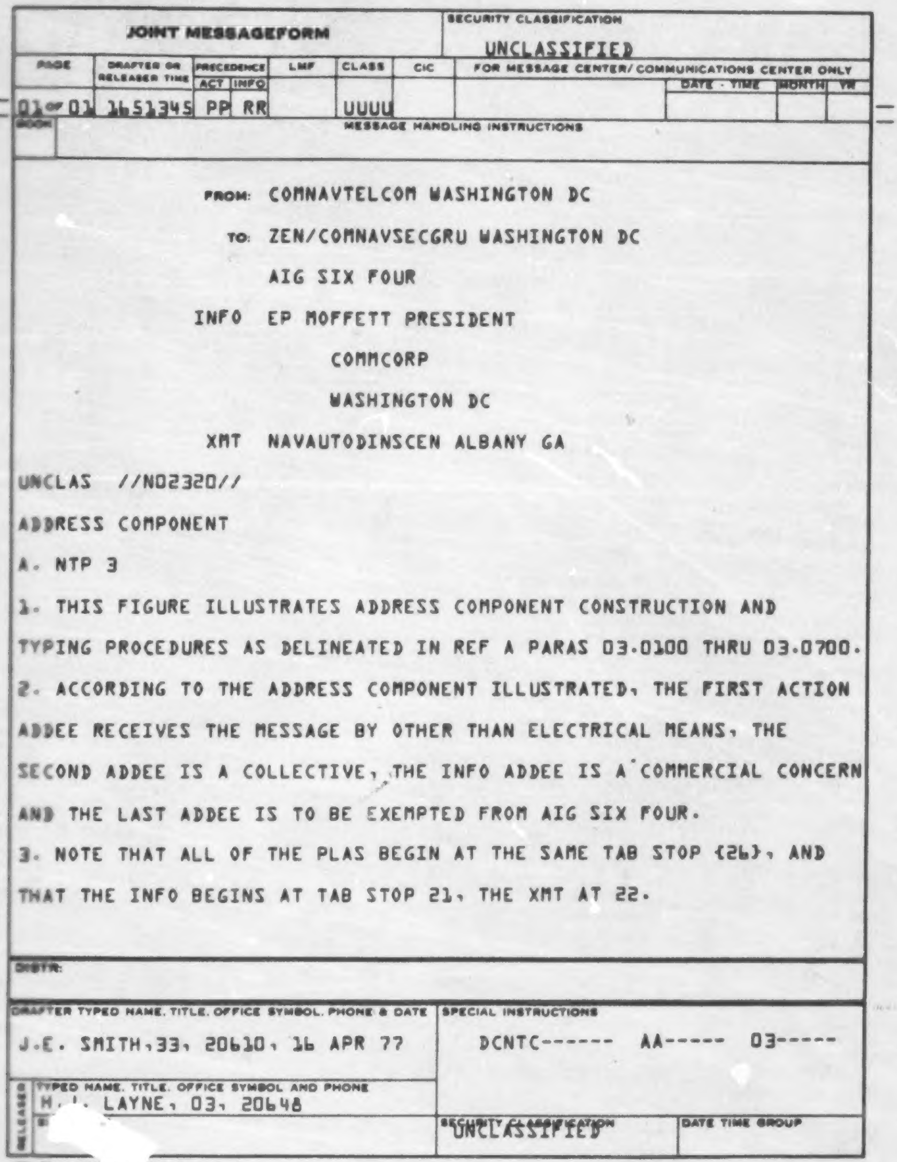
Action or information addressees who have received or who are to receive the message by other than electrical means must be preceded by the operating signal "ZEN," followed by a slant sign immediately before the PLA. The operating signal "ZEN" begins at tab stop 26, the slant at tab stop 29, and the PLA at tab stop 30. The responsibility for ensuring delivery to those addressees designated "ZEN" by the originator, as well as the method of delivery, is assumed by the originator and not the telecommunication center.

CONSTRUCTING THE TEXT

The first line of the text, which is the classification line, begins one double spaced line down from the last addressee, if the text begins on a new page, it should start on the From line of the next page. The first line of the text must contain the message classification, special handling instructions, code or flag words, and the SSIC. (See figure 11-11.)

Classification

The first word of the classification line must be the classification, and this must agree with the four letter character security redundancy code in the Class block. Space must be left



JOINT MESSAGEFORM

SECURITY CLASSIFICATION: UNCLASSIFIED

PAGE	DRAFTER OR RELEASER TIME	PRECEDENCE ACT	PRECEDENCE INFO	LMF	CLASS	CIC	FOR MESSAGE CENTER/COMMUNICATIONS CENTER ONLY	DATE - TIME	MONTH	YR
01 OF 01	161345	PP	RR		UUUU					

BOOK

MESSAGE HANDLING INSTRUCTIONS

FROM: COMNAVTELCOM WASHINGTON DC
TO: ZEN/COMNAVSECGRU WASHINGTON DC
AIG SIX FOUR
INFO EP MOFFETT PRESIDENT
COMMCORP
WASHINGTON DC
XMT NAVAUTODINSCEN ALBANY GA

UNCLAS //N02320//

ADDRESS COMPONENT

A. NTP 3

1. THIS FIGURE ILLUSTRATES ADDRESS COMPONENT CONSTRUCTION AND TYPING PROCEDURES AS DELINEATED IN REF A PARAS 03.0100 THRU 03.0700.

2. ACCORDING TO THE ADDRESS COMPONENT ILLUSTRATED, THE FIRST ACTION ADDEE RECEIVES THE MESSAGE BY OTHER THAN ELECTRICAL MEANS, THE SECOND ADDEE IS A COLLECTIVE, THE INFO ADDEE IS A COMMERCIAL CONCERN AND THE LAST ADDEE IS TO BE EXEMPTED FROM AIG SIX FOUR.

3. NOTE THAT ALL OF THE PLAS BEGIN AT THE SAME TAB STOP (26), AND THAT THE INFO BEGINS AT TAB STOP 21, THE XMT AT 22.

DISTR:

DRAFTER TYPED NAME, TITLE, OFFICE SYMBOL, PHONE & DATE: J.E. SMITH, 33, 20610, 16 APR 77

SPECIAL INSTRUCTIONS: DCNTC------ AA----- 03-----

RELEASER TYPED NAME, TITLE, OFFICE SYMBOL AND PHONE: H. [illegible] LAYNE, 03, 20648

SECURITY CLASSIFICATION: UNCLASSIFIED

DATE TIME GROUP

DD FORM 1 JUL 73 173 (OCR) S/N 0102-001-8000 ★ U.S.G.P.O. J-523-012

76.139

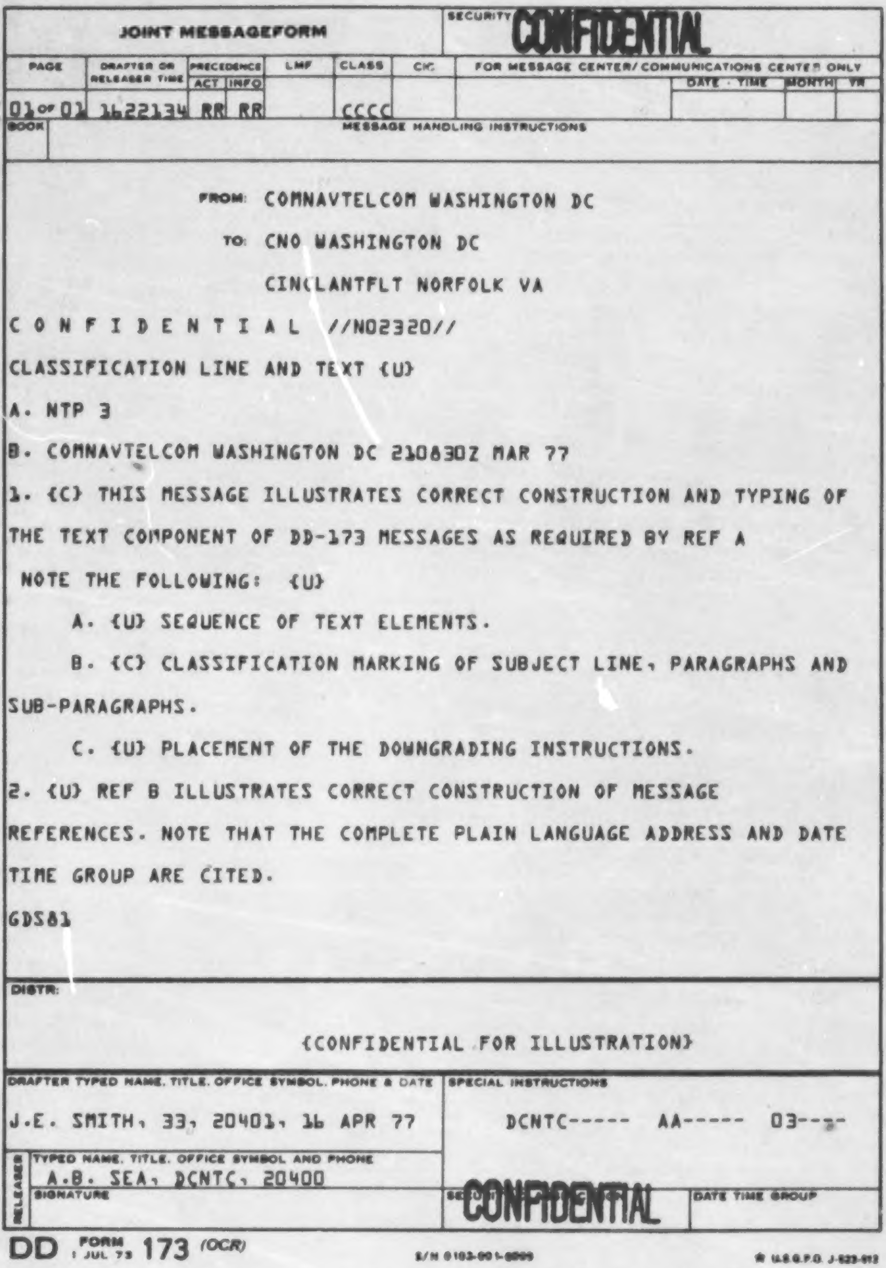
Figure 11-10.—Example of the address component.

between characters in the classification precisely as follows:

UNCLAS
UNCLAS E F T O FOUO
UNCLAS E F T O
CONFIDENTIAL
SECRET
TOPSECRET

Special Handling Markings

Special handling instructions and code or flag words follow the classification. The special markings have the same meanings on the DD-173



JOINT MESSAGEFORM

SECURITY CONFIDENTIAL

PAGE	DRAFTER OR RELEASER TIME	PRECEDENCE ACT	PRECEDENCE INFO	LMF	CLASS	CIC	FOR MESSAGE CENTER/COMMUNICATIONS CENTER ONLY	DATE - TIME	MONTH	YR
01 OF 01	162213Z	RR	RR		CCCC					

BOOK

MESSAGE HANDLING INSTRUCTIONS

FROM: COMNAVTELCOM WASHINGTON DC

TO: CNO WASHINGTON DC

CINCLANTFLT NORFOLK VA

CONFIDENTIAL //N02320//

CLASSIFICATION LINE AND TEXT (U)

A. NTP 3

B. COMNAVTELCOM WASHINGTON DC 210830Z MAR 77

1. (C) THIS MESSAGE ILLUSTRATES CORRECT CONSTRUCTION AND TYPING OF THE TEXT COMPONENT OF DD-173 MESSAGES AS REQUIRED BY REF A NOTE THE FOLLOWING: (U)

A. (U) SEQUENCE OF TEXT ELEMENTS.

B. (C) CLASSIFICATION MARKING OF SUBJECT LINE, PARAGRAPHS AND SUB-PARAGRAPHS.

C. (U) PLACEMENT OF THE DOWNGRADING INSTRUCTIONS.

2. (U) REF B ILLUSTRATES CORRECT CONSTRUCTION OF MESSAGE REFERENCES. NOTE THAT THE COMPLETE PLAIN LANGUAGE ADDRESS AND DATE TIME GROUP ARE CITED.

GDS81

DISTR:

(CONFIDENTIAL FOR ILLUSTRATION)

DRAFTER TYPED NAME, TITLE, OFFICE SYMBOL, PHONE & DATE
J.E. SMITH, 33, 20401, 16 APR 77

SPECIAL INSTRUCTIONS
DCNTC----- AA----- 03----

RELEASER
TYPED NAME, TITLE, OFFICE SYMBOL AND PHONE
A.B. SEA, DCNTC, 20400

SIGNATURE

SECURITY CLASSIFICATION CONFIDENTIAL

DATE TIME GROUP

DD FORM 1 JUL 73 173 (OCR)

76,140

Figure 11-11. — Example of the classification line and text.

as they would on any naval message. These markings must be spelled and spaced exactly as follows:

PERSONAL FOR RADM SMITH
PERSONAL FOR RADM SMITH FROM RADM JONES
LIMDIS
LIMDIS CODE WORK
NAVY EYES ONLY
SPECAT CODE WORD
SPECAT EXCLUSIVE FOR

Immediately following the special handling markings (if any) is the Standard Subject Identification Code (SSIC). This six character code, which is derived from SECNAV Instruction 5210.11 ( ), is preceded and followed by two slant signs.

Passing Instructions and Subject Line

In order to construct a passing instruction, first cite the addressed command's short title, then the office code or individual's name. For example, a message from COMSUBLANT to COMSUBGRU SIX could contain the passing instruction "COMSUBGRU SIX FOR 94G" or "COMSUBGRU SIX FOR RMCS (SS) SMITH." Passing instructions are to be typed consecutively, beginning at tab stop 6, one double spaced line below the classification line.

As shown in figure 11-11, the subject line begins at tab stop 6, one double spaced line below the classification line. When passing instructions are used, the subject line would begin one double spaced line below the last instruction.

Reference Line and Text

As shown in figure 11-11, the first reference line begins at tab stop 6, one double spaced line below the subject line. If there is no subject line, the reference line will begin at the same tab stop, one double space below the classification line or passing instructions. Each reference is lettered consecutively, one beneath the other. The originator's complete PLA should be cited, then the DTG, month and year.

Textual paragraphs are numbered consecutively, each number followed by a period. When necessary for graphic clarity, text lines may be indented a maximum of twenty spaces.

Classification Markings

OPNAVINST 5510.1( ) requires that all electrically transmitted messages be paragraph marked for classification. When the text of the lead-in portion of the paragraph is unclassified but some or all of the sub-paragraphs are classified, the symbol denoting the overall classification of the paragraph will be shown immediately following the paragraph number. The symbol (U) will be shown at the end of the unclassified lead-in portion. (See figure 11-11.)

Whenever different items of information in one paragraph or sub-paragraph require different classifications but separation into paragraphs would destroy continuity or context, the highest classification will be shown. Single paragraph messages with no sub-paragraphs need not be marked for classification. Figure 11-12 illustrates the proper markings used to indicate paragraph and sub-paragraph classifications.

Downgrading and Declassification Markings

Downgrading and declassification markings are typed beginning at tab stop 6, one double-spaced line below the last line of the text. This line will show one of the following:

1. ADS (day, mo, yr)—to indicate advanced declassification for date or event earlier than the General Declassification guidelines.
2. GDS (date)—for General Declassification Schedule guidelines.
3. XGDS (number of exemption category) (last two digits of the declassification year)—to indicate exemption from the General Declassification Schedule.
4. XCL (last two digits of declassification year)—for classifications based on former Group 1, 2, 3, or ungrouped material.

MESSAGE READDRESSALS

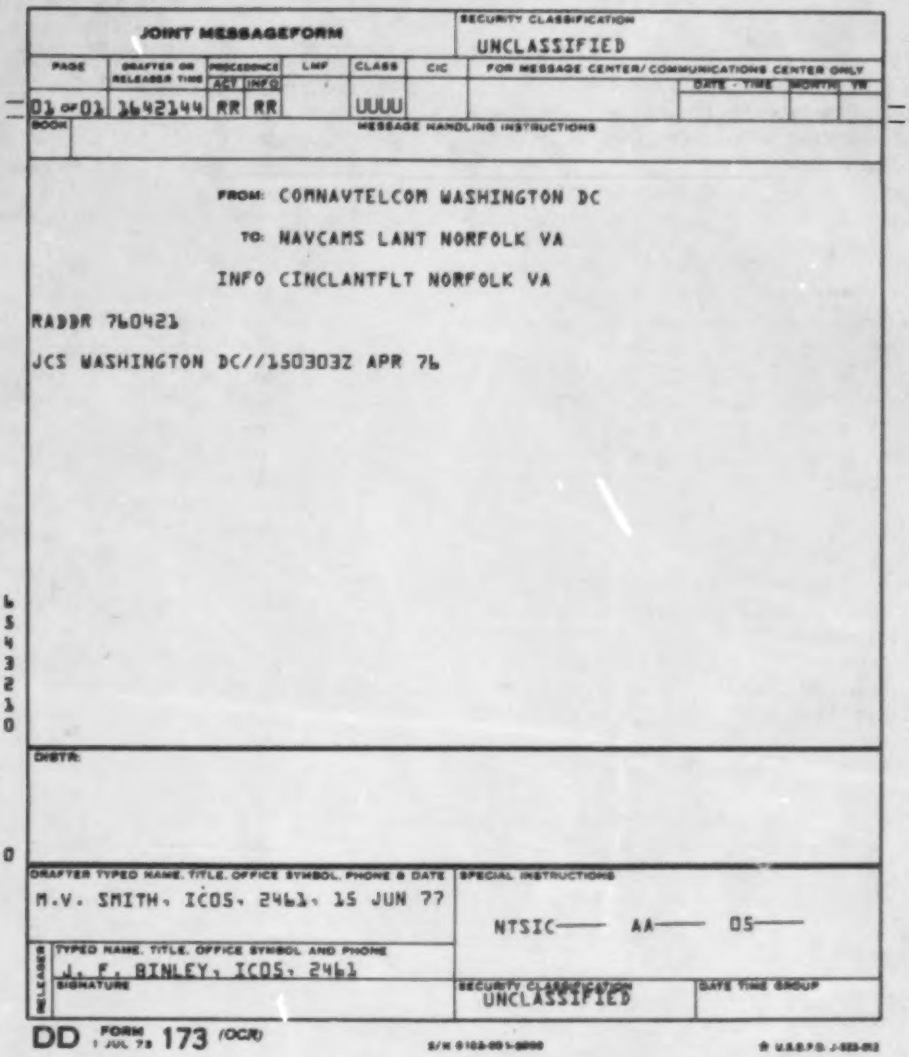
When a message is readdressed on DD-173, the header lines are prepared as already discussed and in accordance with NTP 3 instructions. The activity readdressing the message is the originator of the readdressal, and its PLA is typed on the From line. The action, info, and exempted addees are indicated in the appropriate spaces as previously discussed in constructing the address. Figure 11-13 is an example of the basic information identifying a readdressal.

After the last addressee, at tab stop 6, double space down, and type "RADDR." Next, skip one

Classification	Marking Symbol
Unclassified	(U)
For Official Use Only	(FOUO)
Confidential	(C)
Secret	(S)
Top Secret	(TS)
Restricted Data	(RD)
Formerly Restricted Data	(FRD)
NOFORN	(NFD)

76.147

Figure 11-12.—Classification markings.



JOINT MESSAGEFORM						SECURITY CLASSIFICATION UNCLASSIFIED	
PAGE	DRAFTER OR RELEASER TIME	PRECEDENCE ACT	PRECEDENCE INFO	LMF	CLASS	CIC	FOR MESSAGE CENTER/COMMUNICATIONS CENTER ONLY DATE - TIME / MONTH / YR
01 OF 01	1642144	RR	RR		UUUU		
BOOK	MESSAGE HANDLING INSTRUCTIONS						

FROM: COMNAVTELCOM WASHINGTON DC

TO: NAVCAMS LANT NORFOLK VA

INFO CINCLANTFLT NORFOLK VA

RADDR 760421

JCS WASHINGTON DC//150303Z APR 76

DISTR:

DRAFTER TYPED NAME, TITLE, OFFICE SYMBOL, PHONE & DATE: M.V. SMITH, ICOS, 2461, 15 JUN 77

SPECIAL INSTRUCTIONS: NTSIC—— AA—— 05——

RELEASER TYPED NAME, TITLE, OFFICE SYMBOL AND PHONE: J. F. BINLEY, ICOS, 2461

SIGNATURE:

SECURITY CLASSIFICATION: UNCLASSIFIED

DATE TIME GROUP:

DD FORM 1 JUL 73 173 (OCR)

76.141

Figure 11-13.—Example of Readdressal.

space, and type in the six numeric character Processing Sequence Number (PSN) found at the lower left of the message being readdressed. (The PSN will be found on incoming and back-routed messages processed through LDMX and NAVCOMPARS.) Next, double space down and, at tab stop 6, type the plain language address, two slant signs, and the DTG, MO, YR of the message being readdressed. (See figure 11-13.)

Classification and Precedence

The readdressal request form is unclassified. However, the four character security redundancy code entered in the Class block of the readdressal request form must be the same as the code of the message being readdressed.

The precedence of the readdressal message need not be the same as the message being readdressed. Readdressal messages are formally released like any other message.

SECTION II, SUMMARY

Unless it is used properly, the DD-173 messageform cannot realize its true potential in the areas of efficiency and expediency. When the DD-173 is used properly, communications personnel will find that fewer mistakes, normally resulting in traffic tie-ups and backlogs, are made. This section of Chapter 11 has discussed many of the basic methods necessary to properly use DD-173. However, complete details are found in NTP 3 and should be carefully studied, in addition to the information contained in this section.

CHAPTER 12

RADIOTELEPHONE PROCEDURES

Ashore or at sea, your job as a Radioman will include radiotelephone communications. Uncovered, or non-secure radio transmission is the least secure means of communications, and radiotelephone is the least secure of all. Radiotelephone communications play an important part in day-to-day fleet operations and in the control of coastal and harbor shipping. It is the easiest, most convenient method of relaying real-world situation traffic from ship to ship or from shore to ship because there is no tape to cut and send and no teletypewriter keys to depress. All that is necessary is that you pick up a transmitting microphone and speak into it.

Unless you are using secure voice comminications equipment, it must be assumed that everything you say when using radiotelephone is intercepted. The inherent dangers of interception can be greatly reduced by adhering to the principles of strict circuit discipline. Circuit discipline is attained by the proper use of radio equipment, adherence to prescribed frequencies and operating procedures, proper training, and monitoring. The lack of these things as well as basic negligence, inaccuracy, and laxity are responsible for the violations that endanger the integrity and security of radiotelephone transmissions.

CIRCUIT DISCIPLINE AND SECURITY

Radiotelephone transmissions should be as short and concise as possible consistent with clarity. Often, personnel other than trained operators use radiotelephone equipment. These personnel should be instructed in the proper methods of utilizing the microphone and equipment as well as cautioned in the ease of intercept of the transmission.

Adherence to prescribed operating procedures is mandatory. Deviations from these procedures create confusion, reduce reliability and speed, and tend to nullify security precautions. Once you are armed with information concerning proper procedures, your initiative and common sense can be used to satisfy specific operating requirements. The following is a list of rules to use to enhance proper circuit discipline and transmission security:

1. Do not transmit without proper authorization.
2. Do not violate radio silence.
3. Do not transmit on a directed net without permission.
4. Do not transmit your name or personal sign.
5. Do not excessively tune and test.
6. Do not use unauthorized plain language.
7. DO use authorized prowords.

RADIOTELEPHONE SECURITY

In addition to circuit discipline, proper security precautions must be observed on radiotelephone nets. For example, on tactical nets, many units at sea may be required to use classified call signs. If the operator does not exercise an awareness of the operating situation, the classified call could be linked to the unclassified call sign for that ship. It is for this reason that "BEADWINDOW" procedures have been introduced into radiotelephone procedure.

Beadwindow is a real-time procedure which brings to the immediate attention of circuit operators the fact that an unauthorized disclosure has occurred. It also serves to alert other operators on the net of the disclosure and, thus, acts as an educational aid. The long term benefits from the use of this procedure are the increased awareness to proper use of voice circuits throughout the fleet and, subsequently, an improvement in the security of uncovered Navy voice communications.

Beadwindow procedures deal with Essential Elements of Friendly Information (EEFIs). EEFIs are established by operational commanders and identify specific items of information which, if revealed, would degrade the security of military operations, projects, or missions in the applicable areas. The considered EEFIs, therefore, may vary from operation to operation or from area to area. Table 12-1 is an example of what a group of EEFIs designated for an operation might look like.

The Beadwindow technique requires the use of a code word and number combination which is transmitted immediately to the unit when the code word discloses an EEFI. The code word is used to notify the unit that it has committed the disclosure, and the number provides specific identity of the item disclosed. For example, when any station of the net commits a disclosure of an EEFI, the net control (or any station observing the disclosure) will call the violator with a normal call-up, say the word "Beadwindow" followed by the number of the EEFI that has been disclosed. The reply to the Beadwindow message will be "ROGER OUT." This method allows the reported unit to take immediate action to correct the insecure practice. In this particular situation, if the call of the net control is "Control" and the call of the violator is "Key," the report would be as follows:

"Key THIS IS Control, Beadwindow Three, OVER."

The reply would be: "Control THIS IS Key, ROGER OUT." It should be remembered that procedural violations are not security violations; therefore, they don't fall into Beadwindow criteria.

Table 12-1.—Examples of EEFI

1. Disclosure of impending or intended operations.
2. Disclosure of patrol area boundaries.
3. Disclosure of combat readiness of ships or units.
4. Disclosure of special communication capabilities.

IMPORTANCE OF RADIOTELEPHONE

Poor voice communications, in addition to creating confusion, reducing reliability and speed, and nullifying security precautions, can adversely affect the success of the basic mission of the ship during your present operation.

A commanding officer, regardless of the mission of his ship, has only one "real time" means of communicating with his commander and other units of a force: Radiotelephone. Your ship may be guarding as many as ten (10) or more voice circuits, each having a specific purpose and its own particular procedures. Very few of these circuits will be operated from communication spaces unless you are on a small ship (i.e., a submarine or a destroyer). On relatively large ships, the circuits are handled from the bridge and CIC.

As an operator, you are responsible for providing reliable transmitter and receiver services to these remote operating positions. This entails establishing communications on a net or circuit before making that net or circuit available to the remote operators. If you are not aware of the various nets guarded by your ship and their purpose, the overall communications of the ship will suffer, and the progress of the operation will be impeded.

It should be obvious that modern high-speed naval operations make the elimination of confused radiotelephone operations an absolute necessity. A hunter-killer force searching for an enemy submarine, for example, is not permitted the luxury of a 5- or 10-minute delay in executing a screening signal. This unnecessary delay defeats the purpose (speed) of the OTC in utilizing radiotelephone. A one-minute delay by an aircraft carrier pilot in executing a vectoring signal because he didn't understand the message could easily result in the pilot's death. A submarine during shakedown operations may risk collision with its escort vessel during emergency surfacing procedures if voice communications are not clearly understood.

Whenever possible, use standard phraseology, authorized prowords, and brevity code words. They enhance reliability and clarity. Moreover, variations from standard operating procedures offer an ideal situation for enemy deception on a circuit.

BASIC MESSAGE FORMAT

Radiotelephone (R/T) employs a 16-line message format. (See figure 12-1.) Except when a commercial or International Civil Aviation Organization (ICAO) format is used, each R/T message is prepared in plaindress, abbreviated plaindress, or codress. By far the most common message form in R/T traffic is the abbreviated plaindress. In fact, sometimes the abbreviated plaindress message is so abbreviated that its resemblance to the basic message format is barely discernible. The three major message parts—heading, text, and ending—are there, however. Each of these major parts is reduced to components and elements. All format lines do not necessarily appear in every message; however, when they are used, the lines will be in the order indicated in figure 12-1.

Notice that the order of components and parts shown in figure 12-1 correspond to the order of the basic message shown in chapter 11, BASIC MESSAGE FORMAT. Notice also that "PROWORDS," not prosigns are used in voice communications. These prowords are spoken; so it is important that you, the operator, be completely familiar with those basic to the primary components. Table 12-2 lists many of the commonly used communications phrases and words, their associated proword(s), and explanations of these prowords. Throughout this chapter, prowords are shown in all capital letters.

The following is a discussion of the lines used in the R/T message format listed in figure 12-1.

FORMAT LINES 1, 2, 3, AND 4

Format line 1 is not used in radiotelephone procedure. Format lines 2 and 3 contain the call, the proword "MESSAGE," and the transmission identification.

The call may take one of the following forms:

(1) Full Call -

Washington (station called)

THIS IS

Lincoln (station calling)

(2) Abbreviated Call -

THIS IS

Lincoln (station calling)

Normally, a full call is used to establish communications originally. Once communications are established and no ambiguity will result, an abbreviated call may be used. To further expedite voice communications, the proword "THIS IS" may be omitted by the receiving station when the station is responding to a call, so long as communication conditions are good. Also, when two stations are in continuous communication with each other on a circuit or net not shared by a third station, the call may be omitted entirely provided no confusion will result and communication conditions are good.

When a collective call sign is used and there are addressees that are to be exempted, you do so in the call by the use of the proword "EXEMPT" followed by the call sign(s) of the station(s) exempted. For example:

Edison (collective call)

EXEMPT

Marshall (station exempted)

THIS IS

Lincoln (station calling)

Notice that there is only one station exempted in this call-up; however, if there had been more than one station, they would all have been spoken prior to the proword "THIS IS."

After the call, transmit the proword "MESSAGE" if you wish to indicate that a message which requires recording is about to be transmitted. For example:

Lincoln (station called)

THIS IS

Washington (Station calling)

MESSAGE (message is to follow)

The transmission identification is normally a station serial number and is used mostly in teletypewriter procedure. When used in voice

PARTS	COMPONENTS	ELEMENTS	FORMAT LINE	CONTENTS
H			1	Not used.
	Procedure	a. Call	2&3	Stations called - Proword EXEMPT, exempted calls.
E				Proword THIS IS - station calling.
		b. Message follows		Proword MESSAGE.
		c. Transmission Identification		Proword NUMBER and station serial number.
A		d. Transmission Instructions	4	Prowords RELAY TO; READ BACK; DO NOT ANSWER; WORDS TWICE; Operating signals; Address Groups; Call Signs; Plain Language designators.
D	Preamble	a. Precedence; date-time group; message instructions	5	Precedence designation; Proword TIME: date and time expressed in digits, and zone suffix followed by month indicated by the first three letters, and if required by national authorities, the year indicated by the last two digits; operating signals and proword EXECUTE TO FOLLOW.
I	Address	a. Originator's Sign; Originator	6	Proword FROM. Originator's address designator.
		b. Action Addressee Sign	7	Proword TO. Action addressee designator.
N		c. Information Addressee Sign; Information Addressee	8	Proword INFO. Information addressees designators.
G		d. Exempted Addressee Sign; Exempted Addressee	9	Proword EXEMPT. Exempted addressee designators.
	Prefix	a. Accounting Information, group count	10	Accounting symbol; group count; Proword GROUPS (GROUP NO COUNT)
SEPARATION			11	Proword BREAK
TEXT	Text	a. Subject Matter	12	CLEAR, UNCLASSIFIED, proword SERVICE, and/or internal instructions as appropriate; thoughts or ideas as expressed by the originator.
SEPARATION			13	Proword BREAK
ENDING	Procedure	a. Time Group	14	Proword TIME. Hours and minutes expressed in digits and zone suffix, when appropriate.
		b. Final Instructions	15	Prowords WAIT, CORRECTION, AUTHENTICATION IS, MORE TO FOLLOW, Station designators.
		c. Ending Sign	16	Prowords OVER, OUT

Figure 12-1.—RADIOTELEPHONE (R/T) MESSAGE FORMAT. 76.148

Table 12-2.—R/T Prowords

Proword	Explanation	Proword Equivalent
ADDRESS GROUP	The group that follows is an address group.	
ALL AFTER	The portion of the message to which I have reference is all which follows ______________________.	AA
ALL BEFORE	The portion of the message to which I have reference is all that precedes __________________________.	AB
AUTHENTICATE	The station called is to reply to the challenge which follows.	
AUTHENTICATION IS	The transmission authentication of this message is______________________.	
BREAK	I hereby indicate the separation of the text from other portions of the message.	BT
CALL SIGN	The group that follows is a call sign.	
CORRECT	You are correct, or what you have transmitted is correct.	C
CORRECTION	An error has been made in this transmission. Transmission will continue with the last word correctly transmitted.	EEEEEEEE
	An error has been made in this transmission (or message indicated). The correct version is ________________.	C
	That which follows is corrected version in answer to your request for verification.	C
DISREGARD THIS TRANSMISSION-OUT	This t[illegible]nsmission is in error. Disregard it. T[illegible] proword shall not be used to can[illegible]y message that has been completely transmitted and for which receipt or acknowledgement has been received.	EEEEEEEE $\overline{AR}$
DO NOT ANSWER	Stations called are not to answer this call, receipt for this message, or otherwise to transmit in connection with this transmission. When this proword is employed, the transmission shall be ended with the proword "OUT."	F

Table 12-2.—R/T Prowords—Continued

Proword	Explanation	Proword Equivalent
EXECUTE	Carry out the purport of the message or signal to which this applies. To be used only with the Executive Method.	$\overline{\text{IX}}$ (5 sec dash)
EXECUTE TO FOLLOW	Action on the message or signal which follows is to be carried out upon receipt of the proword "EXECUTE." To be used only with the Delayed Executive Method.	$\overline{\text{IX}}$
EXEMPT	The addressees immediately following are exempted from the collective call.	XMT
FIGURES	Numerals or numbers follow.	
FLASH	Precedence FLASH.	Z
FROM	The originator of this message is indicated by the address designator immediately following.	FM
GROUPS	This message contains the number of groups indicated by the numeral following.	GR
GROUP NO COUNT	The groups in this message have not been counted.	GRNC
I AUTHENTICATE	The group that follows is the reply to your challenge to authenticate.	
IMMEDIATE	Precedence IMMEDIATE.	O
IMMEDIATE EXECUTE	Action on the message or signal following is to be carried out on receipt of the word EXECUTE. To be used only with the Immediate Executive Method.	$\overline{\text{IX}}$
INFO	The addressees immediately following are addressed for information.	INFO
I READ BACK	The following is my response to your instruction to read back.	
I SAY AGAIN	I am repeating transmission or portion indicated.	$\overline{\text{IMI}}$
I SPELL	I shall spell the next word phonetically.	
I VERIFY	That which follows has been verified at your request and is repeated. To be used only as a reply to VERIFY.	

Table 12-2.—R/T Prowords—Continued

Proword	Explanation	Proword Equivalent
MESSAGE	A message which requires recording is about to follow. Transmitted immediately after the call. (This proword is not used on nets primarily employed for conveying messages. It is intended for use when messages are passed on tactical or reporting nets.)	
NET NOW	All stations are to net their radios on the unmodulated carrier wave which I am about to transmit.	
NUMBER	Station Serial Number.	NR
OUT	This is the end of my transmission to you and no answer is required or expected.	
OVER	This is the end of my transmission to you and a response is necessary. Go ahead; transmit.	K
PRIORITY	Precedence PRIORITY.	P
READ BACK	Repeat this entire transmission back to me exactly as received.	G
REBROADCAST YOUR NET	Link the two nets under your control for automatic rebroadcast.	
RELAY (TO)	Transmit this message to all addressees immediately following.	T
ROGER	I have received your last transmission satisfactorily	R
ROUTINE	Precedence ROUTINE.	R
SAY AGAIN	Repeat all of your last transmission. Followed by identification data means "Repeat ____________ (portion indicated)."	
SERVICE	The message that follows is a service message.	SVC
SIGNALS	The groups which follow are taken from a signal book. (This proword is not used on nets primarily employed for conveying signals. It is intended for use when tactical signals are passed on non-tactical nets.)	

Table 12-2.—R/T Prowords—Continued

Proword	Explanation	Proword Equivalent
SILENCE (Repeated three or more times)	Cease transmissions on this net immediately. Silence will be maintained until lifted. (When an authentication system is in force the transmission imposing silence is to be authenticated.)	$\overline{HM}\ \overline{HM}\ \overline{HM}$
SILENCE LIFTED	Silence is lifted. (When an authentication system is in force the transmission lifting silence is to be authenticated.)	
SPEAK SLOWER	Your transmission is at too fast a speed. Reduce speed of transmission.	
STOP REBROADCASTING	Cut the automatic link between the two nets that are being rebroadcast and revert to normal working.	
THIS IS	This transmission is from the station whose designator immediately follows.	DE
TIME	That which immediately follows is the time or date-time group of the message.	
TO	The addressees immediately following are addressed for action.	TO
UNKNOWN STATION	The identity of the station with whom I am attempting to establish communication is unknown.	$\overline{AA}$
VERIFY	Verify entire message (or portion indicated) with the originator and send correct version. To be used only at the discretion of or by the addressee to which the questioned message was directed.	J
WAIT	I must pause for a few seconds.	$\overline{AS}$
WAIT-OUT	I must pause longer than a few seconds.	$\overline{AS}\ \overline{AR}$
WILCO	I have received your signal, understand it, and will comply. To be used only by the addressee. Since the meaning of ROGER is included in that of WILCO, the two prowords are never used together.	

Table 12-2.—R/T Prowords—Continued

Proword	Explanation	Proword Equivalent
WORD AFTER	The word of the message to which I have reference is that which follows___________.	WA
WORD BEFORE	The word of the message to which I have reference is that which precedes .	WB
WORDS TWICE	Communication is difficult. Transmit(ting) each phrase (or each code group) twice. This proword may be used as an order, request, or as information.	
WRONG	Your last transmission was incorrect. The correct version is_________________.	

communications, however, the transmission identification will be the last element of format lines 2 and 3 and will consist of the station serial number preceded by the proword "NUMBER."

Format line 4 contains the transmission instructions which may consist of prowords "RELAY (TO)," "WORDS TWICE," "DO NOT ANSWER," or "READ BACK." The use of these words is explained later in this chapter.

FORMAT LINE 5

This format line contains the precedence, date-time group (DTG), and any necessary message instructions. When a date-time group is transmitted orally the precedence is spoken (e.g., "PRIORITY"), and the DTG itself is preceded by the proword "TIME." For example: "Lincoln THIS IS Polk, PRIORITY, TIME, Three Zero One Four Four Five Zulu."

Message instructions are not normally required in R/T messages. When included, they consist of short and concise instructions which indicate the status of the message and remain with it until the station of destination is reached. For example, if the message is a suspected duplicate, the phrase "This Message Is A Suspected Duplicate," will immediately follow the DTG.

FORMAT LINES
6, 7, 8, AND 9

These format lines form the address of the message and are recognized by the prowords "FROM," "TO," "INFO," and "EXEMPT," respectively. Whenever the originator and the addressee are in direct communication with each other on the same circuit, the call may serve as the address. Figure 12-2 is an example of an R/T transmission showing elements of the heading components (lines 2 through 9).

FORMAT LINE 10

This line is identified by the proword "GROUPS" and may contain the accounting information and group designation. Accounting symbols are seldom used on R/T circuits, but they may appear on messages received for relay over R/T circuits. These accounting symbols are a combination of letters used to indicate the agency, service, or activity which assumes financial responsibility for the message.

R/T messages are usually short, and a group count is seldom used. If the group count is sent, the number of groups will be preceded by the proword "GROUPS" and will appear in the message prefix. When groups are not counted, the prowords "GROUP NO COUNT" will be used in messages which bear an accounting symbol.

FORMAT LINES
11 THROUGH 16

Format line 11 contains the proword "BREAK," and separates the heading from the text. It is not necessarily used but should be used whenever confusion between the heading and text is possible.

Transmission

LINCOLN (Collective Call)

This is

POLK

MESSAGE

PRIORITY

TIME

THREE ZERO ONE FIVE ONE ZERO ZULU

FROM

POLK

TO

LINCOLN

INFO

KEY

EXEMPT

EDISON (Exempted addressee from Collective Call)

76.149

Figure 12-2.—R/T message showing all possible elements of the address component.

Format line 12 is the text of the message and expresses the idea of the originator. The primary difference between an R/T text and that of other types of communication is that an R/T text must be spoken. Therefore, it is of primary importance for would-be operators to thoroughly familiarize themselves with the proper phrases and prowords that are commonly used in communications texts.

Format line 13 contains the proword "BREAK" separating the text from the ending. It should be used when confusion between the text and the ending is likely.

Format line 14 is used only when a time-group is transmitted here and takes the place of a DTG in format line 5. For example, sometimes a DTG is not determined prior to transmission. It may be omitted in format line 5, therefore, and sent as a time-group in format line 14. It consists of the proword "TIME" followed by the time-group plus the zone suffix. For example, if you are in time zone "B" and send a time-group in format line 14, it might be spoken:

TIME

Three One Zero Eight Five Zero

Bravo (Time Zone)

meaning "310850B."

Format line 15 contains any final instructions that are necessary. It is identified by the prowords "WAIT," "CORRECTION," "AUTHENTICATION IS," or "MORE TO FOLLOW."

Format line 16 is identified by the prowords "OVER" or "OUT." Every transmission ends with either "OVER" or "OUT," except that the proword "OVER" may be omitted when two stations are in continuous communication with each other on a circuit not shared with a third station. In all transmissions where the proword "DO NOT ANSWER" is used, the transmission must be ended with the proword "OUT."

CIRCUIT PROCEDURES

There are many procedures associated with radiotelephone. Much of what is done and said over an R/T circuit has to be a result of proper techniques and training, coupled with common sense and experience. There is no logical method to cover every conceivable situation that may arise when voice communication is used. There are many simple procedures that are basic to R/T and arise time and again on these circuits. It is these procedures along with their operating rules that we are going to discuss in this section of the chapter.

VOICE COMMUNICATION REQUIREMENTS

Voice communication requirements may be grouped into two basic categories: Operational/Tactical and Administrative.

Operational or tactical nets apply to most voice circuits used at sea, even though some circuits are often used to pass administrative traffic. These types of circuits can be subcategorized into two distinct types:

1. Short Range
2. Long Range

Administrative circuits may include both short and long-range communications but apply mostly to voice circuits used in port.

Short-range operational communications normally utilize the UHF frequency spectrum (225-400 MHz) and low-power, line-of-sight equipment. Because of these frequency and equipment characteristics, the effective range usually is 20 to 25 miles. This limited UHF range offers no security, and transmissions are always subject to enemy interception. Transmissions, however, are limited somewhat to the local geographic area, making interception more difficult. On the other hand, UHF communications may be extended in range through the proper use of relay procedures.

More and more, ships must report to OTCs from long distances. Long-range frequencies in the medium and high frequency spectrum (2 - 32 MHz), therefore, are used. As discussed in chapter 6, the propagation characteristics of these frequencies make them desirable for long-range communications. Further increasing the range capabilities of long range communications are single-sideband (SSB) methods (previously discussed in chapter 3).

Administrative nets are normally used in port. Included in the administrative category are voice circuits that are neither operational nor tactical. Seldom is there such a circuit in at-sea communication plans. Examples of administrative nets are harbor common circuits and tug control nets. Naturally, these nets take on an operational function during any situation requiring emergency procedures (e.g., natural disasters, civil uprisings, etc.). Circuit requirements vary from port to port as established by the Senior Officer Present Afloat (SOPA). Both the UHF and MF/HF spectrums may be used for administrative nets.

LOCAL HARBOR CIRCUITS

Voice call signs in JANAP 119 are pronounceable words taken from the English language. They are for tactical use and are designed to facilitate speed on tactical radio circuits. These voice call signs, when assigned to specific units or activities, do not provide security of address.

Administrative shore activities are not assigned voice call signs in JANAP 119. Consequently, a ship cannot use a tactical call on administrative ship-shore circuits. When operating on ship-shore radiotelephone circuits, ships may use their international call signs, spoken phonetically. For example, international call sign NOKB is spoken "November Oscar Kilo Bravo." Also available for use is the procedure described in the next paragraph.

In U.S. ports and U.S.-controlled ports overseas, names of ships serve as voice call signs. As a rule, the "USS" prefix, hull designations and numbers, and first names or initials of ships need not be included in the voice call unless they are essential for clarity. The same is applicable to shore activities on administrative nets. The activities may use their administrative title in an abbreviated form, consistent with clarity. For example, a Mobile Technical Unit 2 may have a voice call of "MOTU" on an administrative circuit.

Port authorities controlling local harbor voice circuits are identified by the word "CONTROL." For example, if the USS Francis Scott Key (SSBN 657) is entering port in New London, CT, its initial call to New London Control in order to check into the local harbor net would be:

"Control THIS IS Key, OVER."

If the Key were to call the Fuel Control, their call would be:

"Fuel Control THIS IS Key, OVER."

Remember that the simplified type of call is authorized only in U.S. ports or U.S.-controlled ports. If a ship is in a port that is not under U.S. control, it must conform to the international practice of using phoneticized international call signs on radiotelephone circuits.

TYPES OF NETS

There are two types of R/T nets: Directed and Free. The type of net used is determined by the operational situation. Regardless of the type of net used, a Net Control Station (NECOS) is assigned to monitor the circuit or circuits and enforce circuit discipline. Enforcement of circuit discipline, however, is not the only reason for having a net control station. Sometimes there are so many stations sharing a common circuit that a net control station is necessary to facilitate the efficient handling and passing of R/T traffic. The following is a discussion of the two types of nets.

Directed Net

In this type of net, stations are required to obtain permission from the net control station prior to communicating with other stations in the net. The exception to this rule is when a station has FLASH traffic to send. Also, transmissions on a directed net may be accomplished in accordance with a predetermined schedule.

Free Net

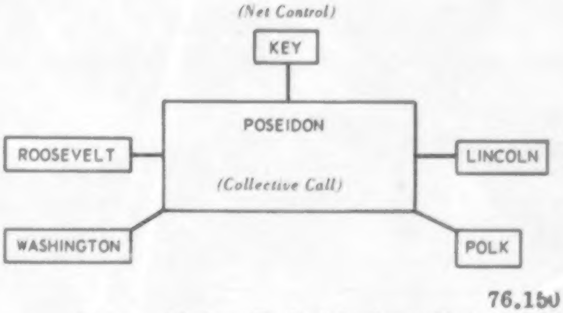
In this type of net, member stations need not obtain permission from the net control station in order to transmit. A free net, however, does not relieve the net control station of the responsibility for maintaining proper circuit discipline.

It is common for both free and directed nets to have a collective call sign. For example, figure 12-3 diagrams a radiotelephone net that consists of the following stations: Key, Lincoln, Polk, Washington, and Roosevelt. For this example, assume that the net control station (NECOS) is Key. Notice that the collective call sign for the entire net is "Poseidon."

OPENING THE NET

The responsibility for opening the net for the first time or reopening the net after it has been temporarily secured belongs to Key. (See fig. 12-3.) To accomplish this on a free net, Key would transmit:

"Poseidon, THIS IS Key, OVER."



76.150

.Figure 12-3.—Radiotelephone Net.

After the transmission, all stations answer in alphabetical order:

> "Key, THIS IS Lincoln, OVER,"
> "Key, THIS IS Polk, OVER," etc.

After all stations on the net have answered, Key then sends:

> "Poseidon, THIS IS Key, OUT."

This last message from Key informs all stations that their transmissions were heard and that he has no traffic for them at the time.

If for some reason a station does not reply to the collective call within approximately 5 seconds, the next station would answer in proper sequence. Then, if possible, the delinquent station will answer last. If the station concerned is having some difficulty that prevents an answer to the call, it reports in to the net as soon as possible with the transmission:

> "Key, THIS IS (name of station).
> Reporting In To Net, OVER."

At this time on a free net, the stations concerned would go about the business of transmitting traffic to each other, following a preliminary call. For example, if Lincoln has traffic for Washington, it would let Washington know this with the call:

> "Washington, THIS IS Lincoln, OVER."

Washington would acknowledge with:

> "Lincoln, THIS IS Washington, OVER."

Lincoln would then send its traffic.

On a directed net, when all communications over the net are to be controlled by the net control station, Key would call the member stations and announce that the net is directed. In this initial transmission, he would request information on the status of any messages outstanding. For example:

> "Poseidon, THIS IS Key, This Is
> A Directed Net, Of What Precedence
> And For Whom Are Your Messages,
> OVER."

Each subordinate station then answers in order, indicating its traffic on hand. For example:

> "Key, THIS IS Lincoln, I Have
> One IMMEDIATE And One PRIORITY
> For You, OVER,"
>
> "Key, THIS IS Polk, No Traffic,
> OVER,"
>
> etc. . . . . .

After all stations have checked into the net, Key would "ROGER" for the transmissions and commence to clear traffic in the order of priority. For example:

> "Poseidon, THIS IS Key, ROGER,
> Lincoln Send Your IMMEDIATE,
> OVER."

When Lincoln has sent and obtained a receipt for its transmission, net control then gives permission to transmit to the station with the next highest precedence traffic.

After the initial traffic is cleared, stations having messages to transmit to other stations on the net must first obtain permission from net control to do so. For example:

> "Key, THIS IS Roosevelt, I Have
> One ROUTINE For Polk, OVER."

Net control would then answer:

> "THIS IS Key, Send Your Message,
> OVER."

It is easily seen that circuit discipline is a necessity. In fleet operations, whether it is a ship entering port or a major fleet exercise, voice communications are required. The number of necessary circuits and nets will increase with the complexity of the task at hand and the number of units participating. Whether the net is free or directed, therefore, the net control station has a large responsibility in expediting message traffic. It should also be stressed that each station is tasked with the responsibility of assisting net control in the proper passing of traffic. Adherence to proper operating procedures and communication standards is the only thing that will keep a net free of backlogs and tie-ups.

R/T CIRCUIT LOGS

Circuit logs should be maintained on all radiotelephone nets or circuits when practicable. The circuit log shows a complete and continuous record of transmitted and received traffic, as well as operating conditions which occur during the watch. The log should include such data as the following:

1. Times of opening and closing by individual stations.
2. Causes of delays on the circuit.
3. Frequency adjustments and changes.
4. Unusual occurrences such as procedural and security violations.
5. Changing of the watch.

When operating conditions permit and when there are no instructions to the contrary, every transmission heard by an operator should be recorded, regardless of the source or completeness. This rule applies to all tactical, command, and reporting nets. On others, a modified log may be kept.

Some nets may require only a modified log for ready reference. On all nets/circuits that require complete logs, however, automatic recording devices should be utilized in order to ensure a total record. Time should be automatically or manually recorded at intervals not exceeding five minutes.

When a message is addressed to or is to be relayed by the receiving station, the message must be written in full on a message blank. Thus, only sufficient details need be inserted in the radio log to identify the message. If the message need not be recorded in full on a message blank, the transmission should be recorded as completely as practicable in the circuit log.

When opening a new circuit or starting a new day's log, the operator should write or type in his name and rank/rate or grade in full. When an operator is relieved or closes the circuit, he must sign the log. The oncoming operator then writes or types his name and rank/rate or grade in full in the log.

Log entries must not be erased. Any necessary changes are made by drawing a single line through the original entry and indicating the changed version adjacent to the lined out entry. Such changes should be initialed by the operator making the change.

THE PHONETIC ALPHABET

Many letters of the alphabet sound similar. For this reason, the standard phonetic equivalents of the letters of the alphabet are used in radiotelephone communications. Usage of the phonetic alphabet saves the many corrections and constant repetitions that would otherwise be necessary. The following is the alphabet with a list of its phonetic and spoken equivalents. The capitalized portions of the spoken equivalents are the parts of the word that should be given the greatest emphasis when spoken:

Letter	Phonetic Equivalent	Spoken
A	ALFA	AL fah
B	BRAVO	BRAH voh
C	CHARLIE	CHAR lee
D	DELTA	DELL ta
E	ECHO	ECK oh
F	FOXTROT	FOKS trot
G	GOLF	GOLF
H	HOTEL	hoh TELL
I	INDIA	IN dee ah
J	JULIETT	JEW lee ett
K	KILO	KEY loh
L	LIMA	LEE mah
M	MIKE	MIKE
N	NOVEMBER	no VEM ber
O	OSCAR	OSS cah

Letter	Phonetic Equivalent	Spoken
P	PAPA	pah PAH
Q	QUEBEC	kay BECK
R	ROMEO	ROW me oh
S	SIERRA	see AIR rah
T	TANGO	TANG go
U	UNIFORM	YOU nee form
V	VICTOR	VIK tah
W	WHISKEY	WISS key
X	XRAY	ECKS ray
Y	YANKEE	YANG key
Z	ZULU	ZOO loo

When signals from naval signal books are transmitted by voice, names of flags (Alfa, Bravo, etc.) are used as they appear in the signal books. Difficult words within the text of plain text messages may be phonetically spelled, using the phonetic alphabet, preceded by the words "I SPELL." When the operator can pronounce the word to be spelled, he does so before and after the spelling of the word to be identified. For example, a phrase in a plain text message might contain the words "Kisatchie Reservation". Upon reaching these two words, the operator would say: . . . . . ."Kisatchie, I SPELL, Kilo, India, Sierra, Alfa, Tango, Charlie, Hotel, India, Echo, Kisatchie, Reservation". . . . . .(rest of text).

Whenever a text is composed of pronounceable words, the words will be spoken as such. Where a text is encrypted, the groups are to be transmitted by the phonetic equivalents of the individual letters and without the proword "I SPELL." For example, the encrypted group "DRSRM" will be spoken, "Delta, Romeo, Sierra, Romeo, Mike," and counted as one group.

PRONUNCIATION OF NUMERALS

Care must be taken to distinguish numerals from similarly prounounced words. To do so, the proword "FIGURES" may be used preceding such numbers. For example, if the text of a radiotelephone message contains the phrase: "From Ten Companies," there is a possibility that the phrase would sound like "From Tin Companies" if spoken as it is written. An operator, therefore, could use the "FIGURES" proword when this phrase is reached in the text by saying, "From FIGURES One Zero Companies." It should be pointed out, however, that the proword "I SPELL" could be used here. For example, upon reaching the same phrase in the text of a message, an operator could transmit as follows: "From Ten, I SPELL, Tango, Echo, November, Ten, Companies." When numerals are transmitted, their correct pronunciation is as follows:

Numeral	Pronounced
0	ZE ro
1	Wun
2	Too
3	Three
4	FO wer
5	Fife
6	Six
7	SE ven
8	Ait
9	NIN er

The numeral "0" is always spoken as "Zero," never as "Oh." Decimal points are spoken as "Day-see-mal."

Generally speaking, numbers are transmitted digit by digit, except that exact multiples of thousands are spoken as such. There are special cases, such as Anti-Air Warfare reporting procedures, where the normal pronunciation of numerals is prescribed and this rule does not apply. For example, in this situation, the number 17 would be pronounced "Seventeen," and not "One-seven." The following is a list of numbers and their normal R/T pronunciation:

Number	Pronunciation
11	Wun Wun
55	Fife Fife
1000	Wun Tou-zand
1920	Wun Niner Too Zero
34,000	Three Fower Tou-zand
349,204	Three Fower Niner Too Zero Fower

DECIMALS, DATES, AND ABBREVIATIONS

The decimal point should be spoken as "DAY-SEE-MAL." For example, 920.4 would be spoken as "Niner Too Zero DAY-SEE-MAL Fower."

Dates should be spoken digit by digit, with the months spoken in full. For example, the date "20 Septmeber" is spoken as "Too Zero September."

There are several rules concerning abbreviations in the text of an R/T message. For example, initials used alone or in conjunction with short titles are spoken phonetically. The phrase "Para A" would be spoken as "Para Alfa." The initials "ACP" would be spoken as "Alfa Charlie Papa."

Personal initials are spoken phonetically, prefixed by the word "INITIALS." For example, the name "D.R. SMITH" would be spoken as "INITIALS Delta Romeo Smith."

Frequently used abbreviations used in normal speech may be used in the same manner when transmitted via radiotelephone. For example, the word "NATO" is spoken as "NATO." The ship "USS Canopus" is spoken as "USS Canopus."

PUNCTUATION

When punctuation is necessary in a radiotelephone message, it should be pronounced as follows:

Punctuation	Spoken
Comma	COMMA
Period	FULL STOP or PERIOD
Parenthesis	PAREN/UNPAREN or OPEN BRACKETS/ CLOSE BRACKETS
Oblique Stroke	SLANT
Quotation Marks	QUOTE/UNQUOTE
Hyphen	HYPHEN
Colon	COLON
Semicolon	SEMICOLON
Dash	DASH

Roman numerals must be transmitted as the corresponding Arabic numerals, preceded by the word "ROMAN." For example, the Roman numeral III would be pronounced, "ROMAN Three."

USE OF OPERATING SIGNALS

Operating signals are not designed for radiotelephone transmission. In R/T procedure, operating information is normally conveyed in concise phrases. It is permissible, however, to use operating signals contained in ACP 131 instead of standard R/T phrases in the following instances:

(1) Where there are language difficulties.

(2) Where practical and where there is no risk of confusion.

270

In such instances, operating signals should be transmitted using authorized phonetic equivalents.

USE OF PROWORDS

Table 12-2 contains a listing of prowords that are authorized for general use. Prowords are used to expedite message handling on circuits where R/T procedures are employed. In no case must a proword or combination of prowords be substituted for the textual component of a message. Between units of different nationalities, prowords may be replaced by their equivalent prosigns, where these exist, spelled out using the authorized phonetic equivalents.

RADIOTELEPHONE CALL SIGNS

Radiotelephone call signs may be assigned by OPORDER, tactical COMMPLAN, or permanently via a commonly-held communications publication. They may be of a permanent or temporary nature, and they may be internationally usable or locally promulgated. In any event, the call signs identify the station and are used to establish communications.

It is required that a ship use its call sign when a net is first established or when the ship is reporting into a previously established net. After this initial contact, an abbreviated form of communications may be used, as discussed earlier. If call sign encryption is in effect and ship/unit names appear in the text, the name should be replaced by the encrypted call sign or address group of the ship or unit. When used in this manner, the call sign or address group may be preceded by the proword "CALL SIGN" or "ADDRESS GROUP" as applicable and as deemed necessary.

ESTABLISHING COMMUNICATIONS

The procedure for calling and answering on a free or directed net has already been discussed. There are times, however, when you must establish communications with a ship or station on temporary basis for the purpose of passing necessary traffic. This consists of no more than a simple call-up to initiate contact and to determine whether communications conditions are good or bad. For example, if the USS Abraham Lincoln wants to contact the USS George Washington on a commonly guarded frequency, the initial call would simply be:

"George Washington THIS IS Abraham Lincoln, OVER."

Upon hearing the initial call, Washington's reply would be:

"Lincoln THIS IS Washington, OVER."

At this point, Lincoln would inititate another call-up and indicate that it has traffic to pass to Washington.

To utilize circuit time more efficiently, all messages or their substance should be written down prior to transmission. Those messages which must be delivered by the receiving operator to another person or which are preceded by the proword "MESSAGE" should be written down.

Transmissions should be clear with natural emphasis on each word except the prescribed pronunciation of a numeral. It is also technically practicable that the sending operator pause after each natural phrase and interrupt the carrier momentarily to allow the other station to break in if necessary. An operator should always listen to make sure that the circuit is clear before initiating a transmission. If it is necessary to initiate test signals either for the adjustment of a transmitter or receiver, such signals should not exceed 10 seconds and should be composed of spoken numerals (1, 2, 3, etc.) followed by the call sign of the station transmitting the signals.

Sequence of Call Signs

Ordinarily, call signs and/or address groups in message headings should be arranged in alphabetical order in the form in which they are to be transmitted, whether plain or encrypted. For this purpose, the slant sign (/) and numerals 1 through 0 are considered the twenty-seventh through the thirty-seventh letters of the alphabet. When abbreviated call signs are used on a net, the sequence of answering a collective call should be the same as if full call signs were in use, thus avoiding any confusion that may arise when these call signs are changed from full to abbreviated.

Signal Strength and Readability

A station is understood to have good signal strength and readability unless the operator is notified otherwise. Queries concerning signal strength and readability should not be exchanged unless one station cannot clearly hear another station. The standard phrase used in a call-up that questions signal strength and readability is the proword "RADIO CHECK." For example, let's assume that USS Abraham Lincoln initiates a call to USS George Washington and wishes to know the status of communications conditions. The initial call would be:

"Washington THIS IS Lincoln, RADIO CHECK, OVER."

Upon hearing this transmission satisfactorily and determining that communication conditions are clear, Washington would then answer:

"Lincoln THIS IS Washington, ROGER, OVER."

The omission of comment on signal strength and readability is understood by Lincoln to mean that the reception is loud and clear. If any adverse conditions existed that were impeding Washington's ability to maintain satisfactory communications, Washington would have used one of the phrases (considered prowords) shown in table 12-3. For example, if the transmission was not considered satisfactory by Washington, the reply might have been:

"Lincoln THIS IS Washington, WEAK and DISTORTED, OVER."

A station that wishes to inform another of signal strength and readability will do so by means of a short and concise report of actual reception such as, "Weak but readable," "Weak with interference," etc. Reports such as "Five by," "Four by four," are not authorized and are not indicative of signal strength and quality of reception.

Good/Bad Communications Conditions

Naturally, the ideal situation exists when atmospheric conditions and interference do not present a problem to successful communications. During good conditions, message parts need only be transmitted once and, depending upon the operational situation, preliminary calls are sometimes optional.

On the other hand, conditions are sometimes anything but ideal, which can present a problem to an inexperienced operator. It should be standard operating procedure to any operator to transmit all call signs twice when communication is bad or difficult. Phrases, words, or groups may be transmitted twice and indicated by the use of the proword "WORDS TWICE." Reception may be verified by use of the proword "READ BACK." For example, if bad communication conditions exist and Lincoln has a message for Washington that reads; "Moor Starboard Side Tender," the transmission would be:

"Washington, Washington, THIS IS, Lincoln, Lincoln, WORDS TWICE, WORDS TWICE, Moor Moor Starboard Starboard Side Side Tender Tender, OVER."

Upon receipt of the message, Washington would then properly ROGER for it. To ensure reception during communications conditions, Lincoln could have ended the above transmission with the proword "READ BACK," sent twice. This would require Washington to read back the message verbatim in words twice form, thus ensuring that it was properly received.

Another method of using "READ BACK" procedure is to do so without using "WORDS TWICE." For example, if Lincoln wanted Washington to read back the message to ensure reception but did not want to use words twice procedure, the transmission would have been as follows:

"Washington, THIS IS Lincoln, READ BACK Text, BREAK, Moor Starboard Side Tender, OVER."

Washington would then answer:

"Lincoln, THIS IS Washington, I READ BACK Text, Moor Starboard Side Tender, OVER."

Table 12-3. — Prowords concerning signal strength and readability.

(1) General -

RADIO CHECK	What is my signal strength and readability, i.e., how do you hear me?
ROGER	I have received your last transmission satisfactorily. The omission of comment on signal strength and readability is understood to mean that reception is loud and clear. If reception is other than loud and clear it must be described with the prowords from subparagraphs (2) and (3) below.
NOTHING HEARD	To be used when no reply is received from a called station.

(2) Report of Signal Strength -

LOUD	Your signal is very strong.
GOOD	Your signal strength is good.
WEAK	Your signal strength is weak.
VERY WEAK	Your signal strength is very weak.
FADING	At times your signal strength fades to such an extent that continuous reception cannot be relied upon.

(3) Report of readability -

CLEAR	Excellent quality.
READABLE	Quality is satisfactory.
UNREADABLE	The quality of your transmission is so bad that I cannot read you.
DISTORTED	Having trouble reading you because your signal is distorted.
WITH INTERFERENCE	Having trouble reading you due to interference.
INTERMITTENT	Having trouble reading you because your signal is intermittent.

Satisfied that Washington has properly received the message, Lincoln would then send:

"Washington, THIS IS Lincoln, That Is Correct, OUT."

In the event that the message had been repeated back incorrectly, Lincoln could have used the proword "WRONG," followed by the correct version. Washington would then repeat back the necessary portions until the message was correctly received in all respects.

When the "WORDS TWICE" or "READ BACK" procedure is used, there are several rules to bear in mind. First, the proword "THIS IS" is not repeated twice, nor is the proword "OVER," when the "WORDS TWICE" procedure is used. They are not spoken twice in the original transmission nor in the repeat back version. Secondly, the proword "ROGER" is not necessary to indicate receipt of the message in the "READ BACK" procedure. If the message is correct in its repeated back version, the phrase that should be used is, "THAT IS CORRECT, OUT."

In a collective call where only some of the stations represented are to read back, those stations should be specified by transmitting their appropriate call signs preceding the proword "READ BACK." When the order to read back is given, only those stations directed to do so will read back; the remaining stations called will keep silent unless directed by the calling station to receipt. When not preceded by identifying call signs, the proword "READ BACK" means that all stations are to read back if the call is a collective one.

CORRECTIONS

When an error is made by a transmitting operator, the proword "CORRECTION" is utilized. The operator then repeats the last word, group, proword, or phrase correctly sent, corrects the error, and proceeds with the message. For example, assume that Lincoln made a mistake in the message to Washington. The correct method for correcting that mistake is as follows:

"Washington, THIS IS Lincoln, Moor Outboard Side, CORRECTION, Moor Starboard Side Tender, OVER."

If the error is not discovered until the operator is some distance beyond it, the correction may be made at the end of the message. For example, assume that USS Francis Scott Key is communicating with USS James K. Polk. During Key's transmission, a mistake is made in the time group but is not discovered until near the end of the transmission. The procedure would be as follows:

"Polk, THIS IS Key, TIME Zero Eight Two Four Zulu, BREAK, Request Status Deep Dive, BREAK, CORRECTION, TIME Zero Eight Two Five Zulu, OVER."

REPETITIONS

When words are missed or are doubtful, repetitions are requested by stations prior to receipting for the message. The prowords most often used for obtaining repetitions are "SAY AGAIN," "ALL BEFORE," "ALL AFTER," "WORD BEFORE," "WORD AFTER," and "TO." For example, in the previous message from Key to Polk, assume that Polk missed the entire message after the word "Request." A repetition for that portion of the message would take the following form:

"Key THIS IS Polk, SAY AGAIN ALL AFTER Request, OVER."

Key would then reply:

"THIS IS Key, I SAY AGAIN ALL AFTER Request-Status Deep Dive, BREAK, OVER."

If the message is satisfactorily received, Polk would then send:

"THIS IS Polk, ROGER, OUT."

The same procedure would also apply to usage of the proword "ALL BEFORE."

Another use of the repetition procedure is requesting that a particular word be repeated. This is done by using either of the two expressions: Prowords "WORD AFTER" and "WORD BEFORE." For example:

"Key, THIS IS Polk, SAY AGAIN WORD AFTER Status, OVER."

Key then replies:

"THIS IS Key, I SAY AGAIN WORD AFTER Status-Deep, OVER."

The same procedure would apply to "WORD BEFORE" procedure by simply substituting the prowords.

The use of the proword "TO" is as follows:

"Key THIS IS Polk, SAY AGAIN Request TO Dive, OVER."

Key would then reply:

"THIS IS Key, I SAY AGAIN Request TO Dive-Request Status Deep Dive, OVER."

Upon satisfactory receipt, Polk would reply:

"THIS IS Polk, ROGER, OUT."

It is an important rule to remember that when repetitions in the heading of a radiotelephone message that contains From, To, Info, or Exempt addees are requested, the prowords are the key to the repetitions procedure. In other words, repetitions may be requested for all of that portion of the heading preceding or following a proword, or that portion between any two prowords. For example, Key sends the following message to Polk:

"Polk, THIS IS Key, MESSAGE, PRIORITY, TIME, Zero Eight Zero Nine Three Zero Zulu, FROM Key, TO Polk, INFO Lincoln, BREAK, Proceed Naval Underwater Sound Laboratories, Rendezvous SAQAD, I SPELL, Sierra, Alfa, Quebec, Alfa, Delta, SAQAD, Representative, BREAK, OVER."

Polk misses the portion of the message before the address and, therefore, sends:

"Key THIS IS Polk, SAY AGAIN ALL BEFORE From, OVER."

Key then sends:

"Polk, THIS IS Key, I SAY AGAIN ALL BEFORE From-Polk, THIS IS Key, MESSAGE, PRIORITY, TIME, Zero Eight Zero Nine Three Zero Zulu, OVER."

Upon understanding the missing portion, Polk sends:

"Key, THIS IS Polk, ROGER, OUT."

The same procedure can be applied to all of the repetition prowords. Just remember that any requests for repetition must include those portions of the heading before, after, or between the applicable prowords.

CANCELLING MESSAGES

Before the ending proword "OVER" or "OUT" is sent, a message transmission can be cancelled by use of the proword "DISREGARD THIS TRANSMISSION, OUT." For example, if Key were in the process of sending the previous message and realizes that the transmission is being sent in error, the process would take the following form:

". . . . . .Proceed Underwater Sound Laboratories, DISREGARD THIS TRANSMISSION, OUT."

After a message has been completely transmitted, it can only be cancelled by another message. For example:

"Polk, THIS IS Key, Cancel My Zero Eight Zero Nine Three Zero Zulu, -TIME Zero Nine Five Zero Zulu, OVER."

Polk Transmits:

"Key, THIS IS Polk, ROGER, OUT."

RECEIPT OF A MESSAGE

No message is considered delivered on a radiotelephone circuit until a receipt is obtained. A receipt is effected by the use of the proword "ROGER." The receiving station can transmit a receipt after each message or after a string of messages if there is more than one message to be receipted for.

In a collective net, when the transmitting station considers speed of handling a primary consideration, one station in the net may be directed to receipt for the message or messages and no other stations may answer until instructed to do so. This, however, does not prohibit any station from requesting repetition.

ACKNOWLEDGMENT OF R/T MESSAGES

An acknowledgment should not be confused with a reply or receipt. An acknowledgment is a reply from an addressee indicating that he received a certain message, understands it, and can comply with the contents of the message. The receipt means only that the message was received satisfactorily. Only the commanding officer or his authorized representative can authorize communications personnel to send an acknowledgment.

A request for acknowledgment is the word "Acknowledge" (not a proword) as the final word of the text. The reply is the proword "WILCO." If the commanding officer can acknowledge at once, the communications operator may receipt for the message with "WILCO" because the meaning of "ROGER" is contained in WILCO. If the acknowledgment cannot be returned immediately, the communications operator receipts for the message with "ROGER," and "WILCO" is sent later. The return transmission to a request for an acknowledgment is either ROGER or WILCO; never both. For example, Polk receives the following transmission from Key:

"Polk, THIS IS Key, Request Special Communications Training, Acknowledge, OVER."

The commanding officer wishes to consider the request before acknowledgment; his operator sends:

"Key, THIS IS Polk, ROGER, OUT."

After due consideration, the commanding officer of Polk understands and can comply with the message. His operator then transmits:

"Key, THIS IS Polk, WILCO, OUT."

VERIFYING AN R/T MESSAGE

When verification of a message is requested, the originating station verifies the message with the originating person, checks the cryptography (if the message is encrypted), and sends the correct version. For example:

"Key, THIS IS Polk, VERIFY Your Zero Eight Zero Nine Three Zero Zulu-SAY AGAIN FROM TO INFO, OVER."

Key then transmits:

"THIS IS Key, ROGER, OUT."

After checking with the originating officer, KEY finds the portion to be verified is correct as transmitted previously and, therefore, sends:

"Polk, THIS IS Key, I VERIFY My Zero Eight Zero Nine Three Zero Zulu, I SAY AGAIN, FROM TO INFO - FROM Key, TO Polk, INFO, OVER."

Polk receipts for the transmission:

"THIS IS Polk, Roger, OUT."

BREAK-IN PROCEDURE

A station having a message of higher precedence than the transmission in progress may break in and, thus, suspend that transmission in the following circumstances:

(1) FLASH messages - The station should break in at once and transmit the message.

(2) IMMEDIATE messages - The station may break in at once and pass the message. A preliminary call may be made before the message is transmitted, if necessary. On a directed net, net control approval must be obtained prior to transmission of the message.

(3) PRIORITY messages - The station should use the same procedure as for IMMEDIATE, except that only long ROUTINE messages should be interrupted.

It should be noted that the break-in procedure is not employed during the transmission of a tactical message except to report an enemy contact. The precedence of the message spoken three times means "Cease transmissions immediately." Silence will be maintained until the station breaking in has passed the message. In the following example, assume that the USS Theodore Roosevelt is transmitting a message to USS George Washington on a free net and USS Francis Scott Key has a FLASH message for USS James K. Polk. Key breaks in with the following:

"FLASH,FLASH,FLASH, Polk THIS IS Key, FLASH, OVER."

POLK replies:

"THIS IS Polk, ROGER, OVER."

Key would then proceed with the Flash traffic and obtain a proper ROGER, thus freeing the net for further transmissions. After hearing Polk's ROGER, Washington re-contacts Roosevelt for the remainder of the traffic that was being sent prior to the break in:

"Roosevelt, THIS IS Washington, ALL AFTER. . . . . ."

On a directed net, the station wishing to break in would first obtain permission from net control. For example, referring to figure 12-3, assume that Lincoln is transmitting a message to Washington and Polk has FLASH traffic for Roosevelt. Polk notifies Key (net control):

"FLASH, FLASH, FLASH,
Key, THIS IS Polk, FLASH For Roosevelt, OVER."

Key then answers:

"Polk THIS IS Key, Send Your FLASH, OVER."

Upon hearing the authorization, Roosevelt transmits:

"THIS IS Roosevelt, OVER."

Polk proceeds:

"Roosevelt, THIS IS Polk, FLASH, (sends message), OVER."

The preceding transmission would conclude after Polk had received a proper ROGER for the FLASH traffic and the two stations that were broken (Lincoln and Washington) would reestablish communications using proper R/T procedure.

EMERGENCY SILENCE

Emergency silence may be imposed on a radiotelephone net only by a recognized, competent authority. If an authentication system is in effect, a station must always authenticate a transmission which:

(1) Imposes emergency silence.
(2) Lifts emergency silence.
(3) Calls stations during periods of emergency silence. When emergency silence is imposed, there is no receipt or answer for such transmissions.

To impose emergency silence, the word "SILENCE" is spoken three times, followed by "OUT." For example, refer to figure 12-3 and assume that Key (net control) were authorized to impose emergency silence. The transmission would be as follows:

"Poseidon, THIS IS Key, SILENCE, SILENCE, SILENCE, TIME One Four Four Zero Zulu, OUT."

To impose emergency silence on a particular frequency but not necessarily on all frequencies used in the net, Key would have used the word "SILENCE" (spoken three times) followed by a frequency or the frequency designator to be silenced. "SILENCE" (spoken three times), followed by the expression "all nets," means "Cease transmissions immediately on all nets."

To lift emergency silence, Key would send the following transmission:

"Poseidon, THIS IS Key, SILENCE LIFTED, TIME One Five One Zero Zulu, OUT."

EXECUTIVE METHOD FOR R/T

The executive method for radiotelephone is used when it is desired to execute a tactical message at a given instant, for example, to ensure that two or more units take simultaneous action. Abbreviated plaindress format is normally used for messages that are transmitted via the executive method and are never to have a time group included in the message ending. There are two executive methods: Delayed and Immediate.

-277

DELAYED EXECUTIVE METHOD

A tactical message sent via the Delayed Executive method will carry the warning proword "EXECUTE TO FOLLOW" in the message instructions immediately preceding the text. The executive signal is sent later in the form of "Standby-Execute," the latter word being the instant of execution. For example, assume that Key sends the following delayed executive method to the collective call "Poseidon," (Refer to figure 12-3):

"Poseidon, THIS IS Key, EXECUTE TO FOLLOW, Fire One Water Slug, OVER."

All stations respond in alphabetical order of full call signs:

"THIS IS Lincoln, ROGER, OUT."
"THIS IS Washington, ROGER, OUT."
"THIS IS Polk, ROGER, OUT."
"THIS IS Roosevelt, ROGER, OUT."

When ready to execute, Key transmits:

"Poseidon, THIS IS Key, Standby, EXECUTE, OVER."

The stations would then respond in alphabetical order of full call signs with:

"THIS IS (station), ROGER, OUT."

In the event that communications are good, Key can designate only one station to receipt for everyone to ensure that the transmission was heard. For example, as part of the execute signal, Key could have transmitted:

"Poseidon, THIS IS Key, Standby, EXECUTE, Polk, OVER."

Polk would then ROGER with:

"THIS IS Polk, ROGER, OUT."

It should be noted that, when considerable time has elapsed between the "EXECUTE TO FOLLOW" message and the actual execution message, the text to be executed should be repeated prior to the words "Standby, EXECUTE." It should also be repeated whenever it is only a portion of a message, or one of several outstanding "EXECUTE TO FOLLOW" messages.

IMMEDIATE EXECUTIVE METHOD

In cases of urgency, the executive signal may be transmitted in the final instructions element of the message to which it refers. The use of the Immediate Executive Method does not allow stations to obtain verifications, repetitions, acknowledgments, or cancellations before the message is executed. These messages should be in plain language or limited to basic TURN, CORPEN, and SPEED signals.

When the Immediate Executive Method is used, the warning proword, "IMMEDIATE EXECUTE" is used in the message instructions instead of the proword "EXECUTE TO FOLLOW." The text of the signal is transmitted twice, separated by the proword "I SAY AGAIN." The executive signal is transmitted in the final instructions. For example:

"Poseidon, THIS IS Key, IMMEDIATE EXECUTE, BREAK, Shift Your Rudder, I SAY AGAIN, Shift Your Rudder, STANDBY, EXECUTE, Polk, Lincoln, OVER."

Notice that Key included both Polk and Lincoln as "ROGER" addees. Again, this is done to ensure that the transmission was received by everyone involved, provided communications are good. If communications were not good, all stations in the net would have to ROGER the execution. Upon hearing their calls, Polk and Lincoln would answer:

"Key, THIS IS Lincoln, ROGER, OUT."
"Key, THIS IS POLK, ROGER, OUT."

AUTHENTICATION

Authentication is a security measure designed to protect a communications system against fraudulent transmissions. There is more than one type of authentication system and the method of authentication will vary with the system that you are using. Authentication systems are accompanied by specific instructions outlining the method of use. Generally speaking, there are two types of authentication:

(1) Challenge and Reply
(2) Transmission

Challenge and Reply authentication occurs when a receiving station suspects the authenticity of a transmitting station and challenges that station to authenticate. In Transmission authentication, the authentication is self-contained within the message.

ENEMY CONTACT REPORTING

Enemy contact reports are normally to be made only once when you are in direct communications with the Officer in Tactical Command (OTC), a higher authority, or a shore radio station. Enemy contact reports are signaled using basic radiotelephone procedure as modified by chapter 6 of ACP 125. Details of enemy contact reporting are contained in ATP 1 (Allied Maritime Tactical Instructions and Procedures, Vol. I). There are two conditions under which enemy contact reports are made more than once:

(1) When "DO NOT ANSWER" procedures are used. (Texts are transmitted twice in this procedure.)

(2) When the text consists of emergency alarm signals, in which case the text is transmitted twice, separated by the proword "I SAY AGAIN," with a time group in the ending.

When in force, authentication should be used in contact reports. Lack of proper authentication, however, should not prevent retransmission or relay of the message to higher authority.

Generally speaking, there are two types of contact reports: Initial and Amplifying. Initial reports, of course, report initial contact or sightings. These should be sent as expeditiously as possible with immediate, pertinent information (type vessel, location, basic track, etc.). The amplifying reports contain all of the necessary amplifying information to be fully analyzed by higher authority or command.

CODE AND CIPHER MESSAGES

Code words (such as VERDIN in the text EXECUTE PLAN VERDIN) are sent as plain language words. Encrypted groups such as DRSRM are spelled phonetically: Delta, Romeo, Sierra, Romeo, Mike.

The phonetic alphabet is applied to the names of the signal flags as well. Signal flags are combined into code groups that have meanings of their own. DELTA ROMEO ONE, for example, might mean "Prepare to Hover." Signal flag A is ALFA, flag B is BRAVO, and so on. Meanings of such code groups are given in appropriate signal publications.

As flag signals are sent by radiotelephone, a Radioman must be able to differentiate between the two when heard. Here is how: If the phonetic alphabet is used, the proword "I SPELL" precedes it, and each phonetic letter is to be recorded as a letter. If you hear "I SPELL" followed by DELTA OSCAR, write it as "DO." On administrative nets, the proword "SIGNALS" followed by DELTA OSCAR means the groups have been taken from a signal book and should be recorded as such. On nets primarily employed for conveying signals, no prowords will be used, and it may be assumed that alphabet flags are intended.

OPERATIONAL BREVITY CODE

The duties of an operator require a knowledge of the special "language" developed for tactical maneuvering, air control, anti-air warfare, naval gunfire support, electronic countermeasures, anti-submarine warfare, and other specialized uses. Words, phrases, and abbreviations employed in radiotelephone for these specialized uses are called operational brevity codes. A complete listing of operational brevity code words is found in the effective edition of ACP 165.

It must be understood that the words and phrases of the brevity code provide no communications security. The purposes of the codes are to:

(1) Standardize the vocabulary,

(2) Improve the accuracy of the transmission,

(3) Shorten transmission time.

SECURITY CONSCIOUSNESS

As a final note, REMEMBER that R/T communications is potentially the least secure of all radio communications. You must be ever alert to avoid disclosure of classified information when transmitting on radiotelephone circuits. The rules and guidelines presented in this chapter should be carefully studied and practiced on training nets. A training net provides an operator with experience in a "classroom" situation without the pitfalls of serious operational mistakes made through panic or inexperience. To further enhance proficiency, the operator should read and study the effective editions of ACP 125 and ACP 165 in addition to this chapter. Those portions of ATP 1 (Vol. I) that deal with contact reporting should also be carefully studied. Remember, when the situation arises in which the operational situation is critical and requires quick action, you do not have time to refer to the applicable publications for proper procedures and security precautions.

CHAPTER 13

MANUAL TELETYPEWRITER PROCEDURES

Teletypewriter (normally referred to as "teletype") is the primary means of communication in the Navy today. Whether you are aboard ship or serving ashore, the final result of automated or manual communications is usually in the form of a teletype printout. In the automated communications area (AUTODIN, Fleet MUX, etc.), the communications operator need only be familiar with write-up and routing/filing procedures peculiar to that command. In the manual communications area, however, the attainment of reliability, security, and speed is determined primarily by the communications operator. Whether the operator is physically operating a ship-to-shore net or cutting a tape for later transmission, the validity of that transmission is determined by his knowledge of proper operating procedures and machine functions.

It is essential that communications operators be well trained, thoroughly understand their responsibilities, and be able to maintain circuit discipline. A manual teletypewriter net is similar to a radiotelephone net in that chaos can result when proper operating procedures are not followed. Reliability, security, and speed are reduced when variations in prescribed procedure create confusion. In this chapter, we will discuss the basic teletype machine functions, operating instructions, and procedures associated with manual teletype procedure. Detailed information concerning these areas is found in the effective edition of ACP 126 (Communications Instructions, Teletypewriter (Teleprinter) Procedures).

MACHINE FUNCTIONS

Machine functions are important in manual teletypewriter procedures because a manually cut tape may enter a relay system that is automatic. In automatic relay systems, messages are rejected or accepted depending upon the proper placement of certain machine functions and the message component sequence. If certain functions are wrong and the message is rejected, a nondelivery results. The machine functions that are cut into teletype tapes also play an important part in the efficient operation of the AUTODIN system (discussed in Chapter 14 of this rate training manual). An explanation of machine functions and rules for their use are given in the ensuing topics.

SHIFT

The "shift" function of a teletype keyboard is comprised of two distinct actions: Shift (FIGS) and unshift (LTRS). Operators must depress the LTRS key when going from upper case to lower case and the FIGS key when going from lower case to upper case. Teletype machines that are owned or leased for use in naval communications shift from upper to lower case only when the LTRS key is pressed. Many naval messages, however, are delivered to addressees via commerical teletypewriter exchange service (TWX). The TWX machines shift automatically from upper to lower case whenever the SPACE bar is pressed, in addition to shifting when the LTRS key is pressed. There are certain basic rules that are observed, therefore, to ensure that the "UNSHIFT-ON-SPACE" feature of TWX machines does not result in errors. These basic rules (to be followed for tape transmission on either a TWX or Navy-owned teletype) are as follows:

(1) Always press the LTRS key to shift from upper to lower case on a TWX or Navy teletype. This has no adverse effect on either type of machine. For example, if "65764 TRY MAKE" were a series of groups sent in the text of a message via a TWX teletype and the (LTRS) function was not inserted originally,

the groups would be received as "65764 546 .-(3" on a Navy teletype.

(2) Always press the FIGS key to shift from lower case to upper case and also after the space before each group of figures or upper case characters in a series. For example, the set of figures "65764 27896" should be sent "65764 (SPACE) (FIGS) 27896". This procedure has no adverse effect on either a TWX or a Navy teletype. This rule applies whether direct keyboard transmission or tape perforation is used. Failure to adhere to this rule will result in the following errors:

(a) As transmitted on a Navy teletype: 65764 (SPACE) 27896.

(b) As received on a TWX machine: 65764 (SPACE) WUIOY.

CARRIAGE RETURN (CR)

The carriage return (CR) function resets the teletype machine to the left margin of the paper. Regardless of typing speed during the cutting of a message tape, the message is transmitted on circuits that generally operate at speeds of 100 words per minute. At these high speeds, the carriage does not have enough time to return to the left margin on a single CR function. As a result, the next character will print while the carriage is still moving toward the left. The CR function, therefore, is always pressed twice to ensure that the carriages return properly on all machines.

LINE FEED (LF)

The line feed (LF) function advances the paper on the page. Part of the end-of-message (EOM) procedure includes eight line feed functions to provide space between messages on a printed teletype page.

SPACE (SP)

The space function advances the carriage (typebox) without printing any characters on the page. It is used throughout the message for spacing between routing information, prosigns, words or groups, and the like.

BELL SIGNAL

The bell signal is used to attract the attention of the receiving operator. On most teletypewriters, the bell signal rings when the upper case "S" key is pressed. Some equipments, however, have the bell signal on the upper case "J" key. The bell signal is transmitted as a series of ten characters, upper case "J" and "S", as follows: (FIGS) JJJJJSSSSS (LTRS).

BLANK (BL)

Pressing the blank key has no effect on the page copy of a message, but it is used to advance blank tape through the punch block of the teletype perforator. The blank function is required in operating certain cryptosystems but is generally used for tape feed out on typing perforators and reperforators. Do not substitute "BL" for "LTRS".

WARNING LIGHT

Tape perforating equipment is equipped with a warning light to indicate the approach of the end of the typing line.

MARGIN BELL

Page printers that are equipped with keyboard facilities capable of operating directly into the line are provided with a margin bell to indicate the approach of the end of the typing line.

MESSAGE ALIGNMENT

In manual teletypewriter procedures there are specific machine functions that are necessary to facilitate the handling of messages and to align the receiving teletypewriters. Just as the previously-discussed functions are necessary for proper keyboard operation, certain message alignment functions are considered necessary for the continuity of operation. The following is a list of basic alignment functions:

(1) All message transmissions must be preceded by five spaces, two carriage returns, and one line feed (5SP, 2CR, 1LF). After the end of message (EOM) functions are sent for one message, the next message is preceded by five spaces, two carriage returns, and one line feed.

(2) The end of line function within the message is two carriage returns and one line feed (2CR, 1LF). This does not apply to format lines only; it applies to any line. Anytime you

prepare to return the carriage in order to begin the next typing line, the procedure is two carriage returns and one line feed.

(3) Between pages of a long message (e.g., PAGE 1 to PAGE 2), the separative function is two carriage returns and four line feeds (2CR, 4LF).

(4) The end of message (EOM) functions are two carriage returns, eight line feeds, the letter "N" repeated four times, and twelve letters (2CR, 8LF, NNNN, 12LTRS). When authorized by separate service instructions, the end of message functions may be altered to require two carriage returns and twelve line feeds.

(5) No line should exceed 69 characters, including spaces, except when authorized by separate service instructions.

MESSAGE PUNCTUATION

Punctuation is not used in manual teletypewriter procedures unless it is absolutely essential to message clarity. When it is necessary to employ punctuation, the following abbreviations and symbols are authorized for use:

Punctuation	Abbreviation	Symbol
Question Mark	QUES	?
Hyphen		-
Colon	CLN	:
Parenthesis Brackets	PAREN	( )
Period/Full Stop	PD	.
Comma	CMM	,
Slant/Oblique Stroke	SLANT	/
Paragraph	PARA	
Quotation Marks	QUOTE-UNQUOTE	

The letter "X" may be used instead of punctuation whenever exact punctuation is not considered essential, but some separation in the text is necessary for clarity, and the use of "X" is not ambiguous. The written phonetic equivalent of the letter "X" should not be used for this purpose. It is advisable that communications personnel encourage message drafters to encircle symbols for periods/full stops and commas when the message is drafted in free hand. These encircled portions are more conspicuous, and errors are less likely to result.

TELETYPE MESSAGE FORMAT

Messages that are processed and handled via teletype are prepared for transmission in either plaindress, abbreviated plaindress, or codress form, except when a commercial form is authorized. Also, there are certain requirements placed upon formatting due to AUTODIN requirements; those are discussed in Chapter 14 of this rate training manual. With the exception of format line 1, manual teletypewriter procedure follows that of the basic message format covered in Chapter 11.

Table 13-1 shows the sequence of basic manual teletypewriter message format and an explanation of each format line. As can be seen, basic message format, radiotelephone format, and manual teletypewriter format are all similar. In each area of formatting, the lines are essentially the same, and the order remains unchanged. Before going any further, however, one topic remains that has not been discussed previously in message formatting: Format line 1.

Format line 1 is used in tape relay procedures as well as in several modes of AUTODIN operation. The various usages of format line 1 in AUTODIN procedures are contained in JANAP 128. Detailed usages of format line 1 with reference to tape relay procedures are contained in ACP 127. The various uses for format line 1 are as follows:

(1) For "pilots" (message handling instructions) when necessary.

(2) For transmission identification (TI), normally in the form of channel numbers.

(3) For start-of-message (SOM) indicators, when necessary.

(4) For "pilot cards" containing special handling instructions in data communications.

(5) For use in several AUTODIN modes of operation in accordance with JANAP 128.

Table 13-1.—Manual Teletypewriter Message Format

	FORMAT LINE		EXPLANATION
Call	2	Designation of stations(s) called; (prosign XMT, exempted calls).	Line 2 - Contains description of the station(s) called; the prosign XMT and designation of exempted station(s). (Lines 2 and 3 may appear as a single typed line.) It may also contain the repeated precedence prosign.
	3	Prosign DE: designation of station calling; transmission identification (station serial number).	Line 3 - The prosign DE; the designation of the calling station and the transmission identification (station serial number). (Lines 2 and 3 may appear as a single typed line.)
Transmission instructions	4	Prosign T; operating signals; address designations; routing indicators.	Line 4 - Contains the transmission instructions and will be identified by the appearance of the prosign T, operating signals, address designations; routing indicators as required.
Precedence; date-time group; message instructions	5	Precedence prosign; date and time expressed in digits, and zone suffix followed by month indicated by the first three letters, and if required by national authorities, the year indicated by the last two digits; operating signal(s).	Line 5 - Will contain the appropriate precedence prosign once and in the case of dual precedence both will be shown separated by a space, the originator's date-time group and message instructions in the form of operating signals as necessary.
Originator's sign; originator	6	Prosign FM; originator's designation.	Line 6 - Is identified by the appearance of the prosign FM and contains the designation of the originator which may be indicated by plain language, call sign or address group.

Table 13-1. — Manual Teletypewriter Message Format — Continued

	FORMAT LINE		EXPLANATION
Action addressee sign; action addressee	7	Prosign TO; address designation(s).	Line 7 - Is identified by the appearance of the prosign TO and contains the designation of the action addressee(s) in the form of plain language, address group(s), call sign(s); or routing indicators.
Information addressee sign; information addressee	8	Prosign INFO; address designation(s).	Line 8 - Is identified by the appearance of the prosign INFO and contains the designation of the information addressee(s) in the form of plain language, address group(s), call sign(s); or routing indicators. A collective designation or an Address Indicating Group (AIG) in Format line 7 may include information addressees.
Exempted addressee	9	Prosign XMT; address designation(s).	Line 9 - Is identified by the prosign XMT and contains the designation of the addressee(s) who is exempted from the collective address designation, when such designation is employed in lines 7 and 8 or an AIG is used in Format line 7.
Accounting information; group designation	10	Accounting symbol; group count.	Line 10 - Is identified by the appearance of the group count prosign and contains accounting symbols (as required) which precede the group count prosign.
	11	Prosign BT.	Line 11 - Separates the heading of the message from the text.
Subject matter	12	Internal instructions; thought or idea expressed by the originator.	Line 12 - Is the text of the message and may contain internal instructions as well as the thought or idea expressed by the originator.
	13	Prosign BT.	Line 13 - Separates the text from the ending of the message.
Time group	14	Hours and minutes expressed in digits and zone suffix.	Line 14 - May contain a time group expressed in digits plus the zone suffix.

Table 13-1.—Manual Teletypewriter Message Format—Continued

FORMAT LINE			EXPLANATION
Confirmation (as required)		Prosign CFN; confirmatory material.	May contain the prosign CFN and confirmed portions of the message as necessary.
Corrections filing time*; final instructions	15	Prosigns, operating signals; necessary corrections; date separated by slant from hour and minutes expressed in digits; plus zone suffix.	Line 15 - Is identified by the appearance of prosign C, operating signals and corrections as required; may contain date and time message was filed with the communication center; final instructions in form of prosigns B; AS; and station designation(s).
Ending sign	16	Prosign K; AR	Line 16 - Is identified by the prosign K or AR as appropriate.

BASIC OPERATING INSTRUCTIONS

Basic manual teletype procedures can be closely equated to basic radiotelephone procedures or to the old "CW" procedures. The primary difference between telephone and teletype procedures is the use of abbreviated equivalents of prowords and separative functions. For example, instead of using the word "Interrogative", you would type "INT" on the keyboard. Instead of using the expression "This is", you would type "DE" on the keyboard.

It should be remembered that the manual teletype procedure is exactly that: Manual. It is assumed that the operator is physically operating a teletype keyboard that is transmitting the desired traffic to receiving stations. Just as in radiotelephone, radioteletype has certain procedures and requirements that are necessary to proper circuit discipline and security. The following topics are discussions of the basic operating instructions that are essential to proper manual communications. Throughout the remainder of this chapter, we will refer to teletype as "TTY".

MANUAL TTY CALLING AND ANSWERING

Establishing communications on TTY normally requires a preliminary call. Preliminary calls may be single, collective, or multiple. A ship or station also may use radio call signs, international call signs, tactical call signs, collective call signs, net call signs, address groups, or theater routing indicators.

Calling

The most common type of TTY call is the single call, usually made on a ship/ship or ship/shore ORESTES net. A single call consists of the transmission of the identification of the station (or stations) with whom communication is desired, the prosign DE, the identification of the station calling, and the prosign K. A single call consists of the identification of a single station or a collective call sign representing more than one station. Both a single and a collective call are shown in examples A and B as follows:

Example A: (Single Station)
(5SP) (2CR) (LF)
NNBD DE NFSK K
(2CR) (LF)

Example B: (Collective Call) In this example, assume that the call sign HZDQ represents a collective of several stations:
(5SP) (2CR) (LF)
HZDQ DE NFSK K
(2CR) (LF)

Those stations that are a part of HZDQ would then answer in alphabetical order.

A multiple call consists of the transmission identification of the stations called, the prosign DE, the identification of the station calling, and the prosign K. The station designations preceding the "DE" will be arranged in alphabetical order, according to the order in which they are to answer. The station designations of a multiple call also should be arranged according to procedural form. For this purpose, figures 1 through 0 and / (slant sign) are considered the twenty-seventh through thirty-seventh letters of the alphabet. When multiple calls are made, care should be exercised to avoid separating groups of related call signs or conjunctive address groups which are interdependent. For example:
(5SP) (2CR) (LF)
NFSK NNBD NOKB DE HZDQ K
(2CR) (LF)
The stations would then answer in the order called.

When multiple calls are made in which there are both action and information addressees, the information addressees must be indicated. This is done with the operating signal "ZFH2", followed by the designation of the information addressees. For example:
(5SP) (2CR) (LF)
NFSK NNBD NOKB DE HZDQ (2CR) (LF)
ZFH2 NNBD NOKB (2CR) (LF)
When all addressees are information, the procedure is as follows:
(5SP) (2CR) (LF)
NFSK NNBD NOKB DE HZDQ (2CR) (LF)
ZFH2 (2CR) (LF)

Answering

In answering a preliminary call, stations will transmit the identification of the calling station, the prosign DE, the identification of the answering station, and the prosign K. For example, HZDQ calls NFSK:
(5SP) (2CR) (LF)
NFSK DE HZDQ K (2CR) (LF)
NFSK then answers:
(5SP) (2CR) (LF)
HZDQ DE NFSK K (2CR) (LF)

After the preliminary calls and answers have been completed, it should be noted that the transmitting station will make 2CR and 8LF prior to transmitting the message. It should be noted also that, just as in radiotelephone procedures abbreviated calls may be made if no confusion will result or if two stations are in direct communication with each other.

If a station fails to answer in proper sequence when a multiple or collective call is employed, the next station waits 5 seconds and then answers. The station which fails to answer in proper sequence must then wait until all other stations have answered or have had time to answer.

When a station fails to answer in sequence and then fails to answer within 5 seconds after all other stations have answered, the calling station should initiate a separate call to raise the station. Also, when any station included in a collective or multiple is specifically directed to answer, no other station included in that call may answer until instructed to do so.

Circuit Test

In the event that a circuit is experiencing communications difficulties or has just been opened, a test may be transmitted as follows:
(5SP) (2CR) (LF)
HZDQ DE NNBD (2CR) (LF)
TEST THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 1234567890 (2CR) (LF)
RYRYRYRYRYRYRYRYRYRYRYRYRYRYRYRYRYRY
(2CR) (LF) K
(2CR) (8LF)
The called station (in this case, HZDQ) would then respond with an answer that includes an appropriate operating signal that indicates the quality of reception.

Transmission Ending

Every transmission should end with the prosigns K or AR. When the prosign AR is used, although no station may receipt, it does not preclude requests for repetitions or verifications, if necessary.

In duplex operation, messages being transmitted should not be interrupted except to respond to received messages of IMMEDIATE precedence or higher and only when the precedence is higher than that of the message being transmitted. If a string of messages is being transmitted by the sending station, responses should occur at the end of each message whenever possible. If multiple page messages are being transmitted, responses should be made after each page.

Message Precedence

The assignment of precedence to a message is the responsibility of the originator and is determined by the subject matter of the text and the time factor involved. Precedence designations are employed to indicate the relative order in which a message of one precedence designation is handled with respect to all other precedence designators. Precedence is indicated by the appropriate precedence prosign and appears as the first element of format line 5. Precedence prosigns indicate the following:

(1) To the originator - the required speed of delivery to the addressee.

(2) To the communications personnel - The relative order of handling and delivery.

(3) To the addressee - the relative order in which the message should be noted.

Messages having both action and information addressees may be assigned two precedences, one precedence for all action addressees and a lower precedence for all information addressees. Where this occurs, the higher precedence will appear first and the two precedence prosigns will be separated by a space. For example, HZDQ has a dual precedence message for NOKB and NNBD:

(5SP) (2CR) (LF)
NOKB NNBD DE HZDQ (2CR) (LF)
O P 101010Z NOV 76 (2CR) (LF)
FM HZDQ (2CR) (LF)
TO NOKB (2CR) (LF)
INFO NNBD (2CR) (LF)
(Rest of message). . . . .

This example indicates that the message is IMMEDIATE to NOKB and PRIORITY to NNBD.

Precedence also may be included in the preliminary call. This is indicated by including the appropriate precedence prosign preceding the ending prosign. For example, HZDQ calls NNBD:

(5SP) (2CR) (LF)
NNBD DE HZDQ O K (2CR) (LF)

This example indicates that HZDQ has IMMEDIATE traffic for NNBD. It should be noted that the bell signal is always transmitted before and after the FLASH precedence prosign in a preliminary call, followed by the prosign K. For example, HZDQ has FLASH traffic for NFSK:

(5SP) (2CR) (LF)
NFSK DE HZDQ (FIGS) JJJJJSSSSS (LTRS) Z (FIGS) JJJJJSSSSS (LTRS) K
(2CR) (LF)

If a sending station wants to indicate a string of messages to be transmitted that are of different precedences, the operating signal "ZBO" may be used, followed by the number of messages to be sent and their precedences. For example, assume that HZDQ has three messages to send to NFSK that are of different precedences. The transmission of the preliminary call should be as follows:

(5SP) (2CR) (LF)
NFSK DE HZDQ ZBO3 O P R K (2CR) (LF)

This preliminary call indicates to NFSK that HZDQ has 3 messages that are outstanding (ZBO3) and their precedences are IMMEDIATE (O), PRIORITY (P) and ROUTINE (R). HZDQ then sends the string of messages in the order of precedence.

Break-In Procedure

When equipment configuration permits, break-in procedure may be employed to interrupt the transmitting station in order to transmit a higher precedence message or to stop the transmitting station because of equipment or receiving difficulties. If a transmission is interrupted for higher precedence traffic, it should be remembered that FLASH and IMMEDIATE traffic may interrupt traffic of lower precedence. PRIORITY traffic, however, should not interrupt ROUTINE traffic unless the ROUTINE traffic is of excessive length. In any event, all precedences are transmitted in the order received and ahead of all traffic of lower precedence.

On simplex circuits, in order to stop the transmitting station, a series of hyphens are transmitted as follows:

(FIGS) A (FIGS) A (FIGS) A . . . . . .etc.

The interrupted station will be immediately informed of the reason for the interruption, if practical. If the interruption is for the purpose of transmitting traffic of a higher precedence, the interrupted station will be so informed, and the higher precedence traffic will be sent. After the interruption, transmission should be resumed at the beginning of the line of copy in which the interruption was made, or, if necessary, the entire message may be retransmitted.

CORRECTIONS

In order to prevent inordinate delays in the receipt of traffic, an operator should have a thorough knowledge of proper correction techniques. There are several methods of correcting errors that are made during manual transmission. The correct method is determined by the location of the error. If an error is made in the text of a message, the operator sends the error prosign "EEEEEEEE" (eight Es) after the incorrect word and resumes transmission by repeating the last word or group transmitted correctly. For example, "CHECK TWO FOUR SUBRAEEEEEEEE FOUR SUBMARINE FRANCIS SCOTT KEY".

If an error is made in the message heading, the error prosign is sent followed by the last prosign or operating signal correctly sent. For example, assume that the operator makes an error in format line 8 (INFO addee):

(2CR) (LF)
TO COMSUBRON SIXTEEN (2CR) (LF)
IFNOEEEEEEEE (2CR) (LF)
TO COMSUBRON SIXTEEN (2CR) (LF)
INFO COMSUBFLOT EIGHT (2CR) (LF)
(. . . .rest of message. . . .)

When a tape is prepared for transmission, two separate procedures are utilized. When errors are made in preparing "chad" or "chadless" tape, the errors may be corrected by backspacing the tape and "lettering out" the errors by means of the LTRS key. The LTRS key punches all five—character columns on the cut tape and will not print a letter or number when those functions are passed through teletype "TD" (transmitter-distributor). When direct communication is used, errors may be corrected by use of the error prosign, using the normal 8Es procedure. Remember, however, that when errors are made in the heading of a message while a tape is cut for transmission, a new tape must be prepared. This is a necessity because error-free and sequence-perfect headings are mandatory in order for the tape to be passed through automatic relay systems.

End of Message Corrections

If an operator discovers an error that was committed earlier in the transmission and not corrected, the error may be corrected at the end of the message. This type of correction is separated from the final BT by (2CR) (LF) and will be preceded by the prosign C. The procedure is very similar to the "word after" and "word before" procedure described in radiotelephone procedure. For example, assume that an operator has discovered an error in the text and wishes to correct it at the end of the message:

(. . . . . .Text of Message. . . . . .) (2CR) (LF)
BT (2CR) (LF)
C WA SUBMARINE - FORCE (2CR) (LF)
K (2CR) (8LF)
(4Ns) (12LTRS)

In the preceding example, the station transmitting the message corrected the word after (WA) "submarine" to read "force", sent the equivalent of phonetic "over" (K), and concluded the transmission with the proper ending procedure of two carriage returns, eight line feeds, four Ns, and twelve letters. The receiving operator would then either "Roger" for the message (R AR) or request further disposition by use of the appropriate operating signals. It must be remembered that when errors in the message heading are corrected in this manner, the entire element in which the error occurred must be repeated.

Multiple-Page Message Corrections

When corrections are necessary in multiple-page messages which were not corrected by lettering out or by use of the error prosign, the corrections should be made following the last textual group on the page where the error appears. Such corrections are separated from the last textual word by (2CR) (LF) and will be preceded by the prosign C. The end of the page functions, (2CR) (4LF), are transmitted after the correction, with the exception that the last page will be ended with the normal message ending and machine functions. In those instances when the error was not noted prior to starting another page, the error should be corrected at the end of the message.

Requests For Repetitions

When a receiving station initiates a request for a correction, sufficient transmission identification and such data as necessary should be used to prevent confusion. For example, if a word or group occurring more than once in a message is used to identify a part of the correction request, it is assumed by the transmitting station that the first occurrence of that word or group is implied. If the first occurrence is not intended, amplifying data such as adjacent words or groups must be included. For example, assume that the term "COMSUBLANT" is used frequently throughout the text of a message, and the receiving operator discovers an atmospheric garble in the received version following one of the usages of COMSUBLANT. If the operator simply asked for the word after (WA) COMSUBLANT, the transmitting operator would not know which usage the correction was requested for and would send the word after the first appearance of COMSUBLANT in the text. The receiving operator's request, therefore, would be better served in the following form:

(5SP) (2CR) (LF)
NOKB DE NFSK IMI WB TRIDENT K
(2CR) (LF)

In the preceding example, NFSK is asking NOKB to repeat (IMI) the word before (WB) TRIDENT in the text of the message. The word TRIDENT appeared after the word following COMSUBLANT, but the receiving operator saved time by requesting the word before TRIDENT rather than having to amplify further a "word after" COMSUBLANT request.

Notice the usage of the operating signal IMI in the preceding example. The definition of IMI is "repeat" and is used whenever a station desires a repetition of a particular message part. If NFSK desired a repetition of the TO to INFO message components, the repetition request would take the following form:

(5SP) (2CR) (LF)
NOKB DE NFSK IMI TO TO INFO K
(2CR) (LF)

If NFSK wanted to request a repetition of the eighth group of an encrypted message, the request would be as follows:

(5SP) (2CR) (LF)
NOKB DE NFSK IMI 8 K
(2CR) (LF)

If NFSK wanted to request a repetition of the entire message after the eighth group, the request would be as follows:

(5SP) (2CR) (LF)
NOKB DE NFSK IMI AA 8 K
(2CR) (LF)

Repetitions Involving "BT"

It should be remembered that the separative sign BT appears twice in the format of a normal message. It is assumed, therefore, that repetition requests involving BT are referring to the first BT. For example, assume that NFSK sends the following transmission:

(5SP) (2CR) (LF)
NOKB DE NFSK IMI AB BT K
(2CR) (LF)

The meaning can be assumed to be all before (AB) the first BT. NOKB would then retransmit the entire heading to NFSK.

If NFSK wanted the entire text repeated, the transmission would take the following form:

(5SP) (2CR) (LF)
NOKB DE NFSK IMI BT TO BT K
(2CR) (LF)

This would indicate to NOKB that NFSK wanted the text only (format line 12) and needed no information that might have been sent after the second BT (format lines 14, 15, and 16). If NFSK wanted both the text and the substance of format lines 14, 15, and 16, the transmission would have been as follows:

(5SP) (2CR) (LF)
NOKB DE NFSK IMI AA BT K
(2CR) (LF)

NOKB would then retransmit everything after the first BT. A situation such as this one could arise whenever there are so many garbles in the received copy that it would be more time consuming to use "word after" or "word before" procedure than to simply repeat the entire text and remaining format lines.

Subject To Correction (SUBCOR) Messages

Occasionally, corrections and repetitions cannot be obtained immediately. Messages received with portions missing or portions of doubtful accuracy should be delivered or forwarded subject to correction (SUBCOR) if the precedence is IMMEDIATE or higher or the operational situation dictates. In local delivery and routing, the missing or doubtful portions should be indicated by appropriate notation on the face of the message. Extreme discretion should be exercised, however, in forwarding or delivering transmissions that are so garbled as to be of no value. It should also be remembered that a station delivering or forwarding a message that is subject to correction is responsible for obtaining and forwarding corrections.

Verifications

Verification requests should be initiated by addressees only and may be in the form of a service or regular message. New messages or service messages that request verification are sent only if the message in question has already been receipted for. Verifications can be requested on a real-time basis as the need arises on a manual TTY circuit. The prosign J (verify with the originator and repeat) can be used in much the same way as the prosign C or the operating signal IMI. For example, assume that NFSK desires a verification of the words "SUBNOTE REQUEST" from a line in the text that reads: "COMSUBLANT REQUESTS SUBNOTE REQUEST PROCEDURES BE IMPLEMENTED." The request for verification would take the following form:

(5SP) (2CR) (LF)
NOKB DE NFSK J REQUESTS TO PROCEDURES K
(2CR) (LF)

After checking with the originator and verifying that the textual words in question are correct as previously transmitted, NOKB would initiate the following:

(5SP) (2CR) (LF)
NFSK DE NOKB J REQUESTS TO PROCEDURES SUBNOTE REQUEST K
(2CR) (LF)

NFSK would then end the exchange with:

(5SP) (2CR) (LF)
NOKB DE NFSK R AR
(2CR) (LF)

CANCELLATIONS

A message may be canceled only by the originator. When a message is in the process of being transmitted, it may be canceled by use of the error prosign E E E E E E E E (8Es) and the ending prosign AR. Each letter of the error sign must be separated by a space. For example, if you are transmitting a message and discover that the transmission is in error, the proper method of cancellation is as follows:

AND PROCEED TO POINT (2CR) (LF)
E E E E E E E E AR
(2CR) (LF)

The 8Es prosign and AR should not be used to cancel a transmission after a receipt has been given. For this purpose, a service message containing appropriate operating signals must be used. A station canceling a transmission is responsible for any further action necessary in connection with the message involved.

COUNTING AND CHECKING GROUPS

Confusion can often result if an operator is not familiar with the basic rules concerning the counting of message groups. The basic rules are as follows:

(1) Count text groups only.
(2) Punctuation and symbols are not counted unless spelled out or abbreviated.
(3) A sequence of characters that is not interrupted by a space is counted as one group.
(4) The letter "X" is counted as one group when used in lieu of punctuation.
(5) The proper names of countries, cities, or streets consisting of two or more separate words should normally be written and counted as one group. For example, NEWLONDON, SANDIEGO, SALTLAKECITY, but when the words are written separately, they should be transmitted and counted as separate groups.

291

Checking Group Count

There are several methods of checking group counts of a message. One method is the use of the operating signal IMI, which means "repeat". For example, if an operator wants the ninth group of a message repeated, the request would take the following form:

```
(5SP) (2CR) (LF)
(Station called) DE (Station Calling)
IMI GR9 K
(2CR) (LF)
```

In this example, the calling station is requesting that the ninth group be repeated.

Another method is by use of the operating signal INT preceding the group symbol GR. When a calling station uses this format, the exchange is assumed to be in the form of a question, meaning "is the number of groups correct as indicated"? For example, assume that NOKB transmits a message to NFSK and transmits the group count as GR9 (meaning that the message has 9 textual groups). Upon receiving the message, NFSK finds that the number of groups received does not correspond to the group count transmitted. NFSK would question the validity of the group count with the following:

```
(5SP) (2CR) (LF)
NOKB DE NFSK INT GR9 K
(2CR) (LF)
```

If NOKB rechecks the message and finds the group count to be correct as transmitted, the prosign C would be used as follows:

```
(5 SP) (2CR) (LF)
NFSK DE NOKB C K (2CR) (LF)
```

Essentially, NFSK asked NOKB, "is the group count correct as transmitted"? NOKB responded, saying "that is correct." The primary difference between the operating signals IMI and INT is that IMI asks for a repeat, whereas INT places the query in the form of a question.

Checking Messages
Under 50 Groups

For plain language and encrypted text messages where the group count does not exceed 50 groups, the transmitting station repeats the original group count and the first character of each word or groups in the text when responding to an INT. For example, assume that NNBD makes the following transmission to NFSK:

```
(5SP) (2CR) (LF)
NFSK DE NNBD            (2CR) (LF)
R 151015Z NOV 76        (2CR) (LF)
GR9                     (2CR) (LF)
BT                      (2CR) (LF)
YOUR SORTIE REQUEST APPROVED IAW COM-
SUBLANT OPORDER APPLICABLE ANNEX
BT                      (2CR) (LF)
K                       (2CR) (8 LF) (4Ns)
                        (12LTRS)
```

NFSK then questions the group count:

```
(5SP) (2CR) (LF)
NNBD DE NFSK INT GR9 K
(2CR) (LF)
```

NNBD checks and finds the group count correct as transmitted, then transmits:

```
(5SP) (2CR) (LF)
NFSK DE NNBD GR9 BT Y S R A I C O A A
BT K
(2CR) (LF)
```

Checking Messages
Over 50 Groups

For checking group count on plain text messages over 50 groups, the procedure is the same as that discussed for those under 50 groups. For encrypted text messages with a group count of over 50 groups, however, the transmitting station repeats the original group count and repeats the first letter of the first, eleventh, and every tenth group following them. For example, assume that NFSK sends the following INT request to NOKB after NOKB has completed transmitting a 76 group encrypted message:

```
(5SP) (2CR) (LF)
NOKB DE NFSK INT GR76 K
(2CR) (LF)
```

NOKB checks and finds the group count correct as transmitted, then transmits:

```
(5SP) (2CR) (LF)
NFSK DE NOKB GR76 BT 1-R 11-M 21-C
31-S 41-S 51-S 61-D 71-R BT K
(2CR) (LF)
```

Notice that NOKB sent the identity of the letter (1st, 11th, etc.) and the letter itself (R, M, etc.).

In the preceding manner, the receiving station can check to see if the sequence of groups has been received correctly. After the transmission of the first, eleventh, and subsequent group letters, the receiving station can then find where the error lies and can send a request for repetition of the ten groups in which there has been a miscount during reception. For example:

```
(5SP) (2CR) (LF)
NOKB DE NFSK IMI 30 TO 40 K
(2CR) (LF)
```

It should be pointed out that the group count of the transmitting station is final.

TRANSMISSION OF MESSAGES

Messages to be transmitted should be sent exactly as intended by the originator. When a message is transmitted, abbreviations should not be substituted for full words or full words for abbreviations without the approval of the originator.

A station receiving a message is responsible for the message until a receipt is obtained from another station or delivery is accomplished. (Messages forwarded by the broadcast services are considered received when transmitted.)

It is important to remember that the number of characters and spaces typed on one line should not exceed 69. Sending operators should type the message in such a manner that a long word falling at the end of a line will not be hyphenated. In order to prevent hyphenating a word at the end of a line, strict attention must be paid to the "end-of-line" indicators (warning light or margin bell).

Multiple Page Messages

Messages containing more than 20 lines of heading and text are divided into pages for transmission as follows:

(1) The number of pages of the message text in any transmission cannot exceed 5. A page consisting of part heading and part text should not count as a textual page.

(2) The first page should consist of not more than 20 lines and should begin with format line 5, counting from format line 5 of the message heading, and continue for a total of 20 lines.

(3) All succeeding pages should contain 20 lines of text, except the last page, which may contain less.

(4) Correction (C) procedures may be used at the end of each page as necessary.

(5) The machine functions between pages should be (2CR) (4LF).

An important point concerning the proper paging of messages should be understood. As stated in condition (1) above, a page consisting of part heading and part text does not count as a textual page. For example, the initial page should have the heading of the message and, barring a long list of action and info addees, a few lines of text. This initial page should not count as one of the textual pages because it contains both heading and textual lines. It should also be pointed out that the lines referred to are not format lines; they are TYPED lines. The first textual page, therefore, should be one which has 20 typed lines of text, not including any element of the heading.

Long Messages

Messages which exceed 5 textual pages are considered to be long messages. Messages such as these are divided into transmission sections. A transmission section cannot exceed five textual pages.

Long messages can monopolize circuit time when transmitted in their entirety. It is sometimes advisable to separate the messages into transmission sections even though they may be less than the prescribed length. Transmission sections should not be confused with cryptoparts as employed in encrypted messages. Normally, messages are separated at a convenient point so as not to destroy the continuity of the message but not beyond the maximum number of pages prescribed.

In unencrypted messages, the marking "SECTION____OF____" is inserted prior to the text or following the security classification, if any. For example, if the marking "SECTION 1 OF 3" is used, each additional transmission section should be preceded by an identical message heading. The only difference should be the station serial number and group count (if any) for that particular transmission section. The final transmission section is identified by "FINAL SECTION OF____."

The following is an example of the correct method of numbering pages and transmission sections of a 1600 group message:

(5SP) (2CR) (LF)

NBA DE NFSK NR1 (2CR) (LF)

T (2CR) (LF)

O 171510Z NOV 76 (2CR) (LF)

FM USS FRANCIS SCOTT KEY (2CR) (LF)

TO COMSUBGRU SIX (2CR) (LF)

COMSUBRON SIXTEEN (2CR) (LF)

COMSUBRON FOURTEEN (2CR) (LF)

INFO COMSUBRON EIGHTEEN (2CR) (LF)

GR750 (2CR) (LF)

BT (2CR) (LF)

SECTION ONE OF TWO (2CR) (LF)

(Twenty lines of heading and text) (2CR) (LF)
(2CR) (4LF)

PAGE TWO NFSK NR1 (2CR) (LF)

(Twenty lines of text) (2CR) (4LF)

(Note: Succeeding pages of this transmission section should appear as shown above. The final page is shown next.)

PAGE FIVE NFSK NR1 (2CR) (LF)

(Final lines of text) (2CR) (LF)

SECTION ONE (2CR) (LF)

BT (2CR) (LF)

K (2CR) (8LF)
(4Ns) (12LTRS)

The second and final transmission section would appear as follows:

(5SP) (2CR) (LF)

NBA DE NFSK NR2 (2CR) (LF)

T (2CR) (LF)

O 171510Z NOV 76 (2CR) (LF)

FM USS FRANCIS SCOTT KEY (2CR) (LF)

TO COMSUBGRU SIX (2CR) (LF)

COMSUBRON SIXTEEN (2CR) (LF)

COMSUBRON FOURTEEN (2CR) (LF)

INFO COMSUBRON EIGHTEEN (2CR) (LF)

GR850 (2CR) (LF)

BT (2CR) (LF)

FINAL SECTION OF TWO (2CR) (LF)

(Twenty lines of heading and text) (2CR) (4LF)

PAGE TWO NFSK NR2 (2CR) (LF)

(Twenty lines of text) (2CR) (LF)

(Note: The succeeding pages of this transmission section should appear in the manner just shown. The final page is shown below.)

PAGE FIVE NFSK NR2 (2CR) (LF)

(Final lines of text) (2CR) (LF)

SECTION TWO (2CR) (LF)

BT (2CR) (LF)

K (2CR) (8LF)
(4Ns) (12LTRS)

In the preceding example, notice that the text is conveniently broken down into 750 and 850 groups, respectively. Also, notice that a separate station serial number is used for each transmission section, although the date-time group and addees remained the same.

USE OF COMMON PROSIGNS

Proper usage of common prosigns can save circuit time and expedite traffic handling procedures. It is important, therefore, that TTY operators have a knowledge of the most used prosigns and their basic definitions.

The following is a list of these common prosigns and their meanings:

PROSIGNS	DEFINITION AND MEANING
AA	All After.
AB	All Before.
AR	End of transmission - "This is the end of my transmission to you, and no response is required or expected."
AS	Wait - (1) AS made during a transmission and without an ending sign indicates a pause for a few seconds. (2) AS followed by AR indicates "You are to wait" or "I am obliged to wait", as applicable.
B	More to follow.
BT	Long Break - "Indicates the separation of the text from other portions of the message or portions indicated."
C	(1) C alone means "You are correct." (2) C followed by identification data means, "This is a correct version of the message or portions indicated." (3) Always used when replying to prosign J.
CFN	Confirmation - "The following confirms a portion of the text."
DE	From - "This transmission is from the station whose designation follows."
EEEEEEEE	Error - A succession of 8 Es indicates that an error has been made. The error sign will be followed by the last word, group, or prosign which was correctly transmitted.
F	Do not answer - "Stations called are not to answer this call, receipt for this message, or otherwise transmit in connection with this transmission."
FM	Originator's Sign - "The originator of this message is indicated by the designation immediately following."
G	Repeat back - "Repeat this entire transmission back to me exactly as received."
GR	Groups - GR followed by numeral(s) means, "This message contains the number of groups indicated."
GRNC	"The groups in this message have not been counted."
HM	(Made 3 times.) Emergency silence sign. "Silence."
IMI	Repeat.
INFO	Information addressee sign.
INT	Interrogatory - Preceding operating signals and prosigns, INT indicates that the matter to follow is in the form of a question. INT preceding a portion of a message means "Is my reception of this correct"?
IX	"Action on the message or signal which follows is to be carried out upon receipt of "EXECUTE."

PROSIGNS	DEFINITION AND MEANING
J	Verify and repeat - "Verify the entire message (or portion indicated) with the originator and send correct version."
K	Go ahead - "This is the end of my transmission to you and a response is necessary. Go ahead; transmit."
NR	Number.
O	Immediate - "The precedence of this message is IMMEDIATE."
P	Priority - "The precedence of this message is PRIORITY."
R	Received - "I have received your last transmission (or messages indicated)."
R	Routine - "The precedence of this message is ROUTINE."
T	Transmit to.
TO	Action addressee sign.
WA	Word after.
WB	Word before.
XMT	Exempt - "Addressees indicated by designation immediately following are exempted from the collective call or address designation."
Z	Flash - "The precedence of this message is FLASH."

AA, AB, and AS

AA (All After) is used to identify requested portions of a message. It is normally used after IMI, C, and J. For example:

```
(5SP) (2CR) (LF)
DE NFSK IMI AA BT K
(2CR) (LF)
```

AB (All Before) is used in the same manner as AA.

AS (Wait) is used in several different ways. It can be made during a transmission and without an ending sign, which indicates a short pause. It can be made with an ending sign, such as AR, to mean "You are to wait." An example of a short pause is as follows:

```
(5SP) (2CR) (LF)

NOKB DE NFSK                  (2CR) (LF)

R    221035Z    NOV  76       (2CR) (LF)

GR15                          (2CR) (LF)

BT                            (2CR) (LF)

MOOR PORT SIDE                (2CR) (LF)

AS                            (2CR) (LF)
```

If the preceding example is transmitted as is, it means that the pause will be a short one. If the transmission were ended with AR, however, it would mean that the wait will be longer than a short pause. In any event, the receiving station is to wait for either a K or AR before transmitting. The exception to this rule would be whenever the receiving station has a message of higher precedence to transmit. If the receiving station has a higher precedence message to transmit, break-in procedure should be employed.

B (More To Follow)

The prosign B means that there is more traffic to follow. For example:

```
(5SP) (2CR) (LF)

NOKB  DE  NFSK                (2CR) (LF)

R    221330Z    NOV  76       (2CR) (LF)

FM USS FRANCIS SCOTT KEY      (2CR) (LF)

TO USS ABRAHAM LINCOLN        (2CR) (LF)

BT                            (2CR) (LF)

(Text)                        (2CR) (LF)

BT                            (2CR) (LF)
```

B (2CR) (LF)

K (2CR) (8LF)
(4Ns) (12LTRS)

The above example indicates to NOKB that NFSK has more traffic to send by the placement of B on the final instructions.

B followed by a numeral means "More to follow, total number of groups transmitted thus far is as indicated." For example, if NFSK were transmitting a 190-group message to NOKB, the procedure should be done as follows:

(5SP) (2CR) (LF)

NOKB DE NFSK (2CR) (LF)

R 221345Z NOV 76 (2CR) (LF)

GR190 (2CR) (LF)

BT (2CR) (LF)

(First 100 groups) (2CR) (LF)

B 100 (2CR) (LF)

K (2CR) (4LF)

In the preceding example, NFSK indicates to NOKB that the number of groups sent thus far is 100 and that there is more to follow. The K indicates that repetition requests will now be taken. It is standard circuit procedure to pause at the end of each 100 groups to allow the receiving station time to request repeats, corrections, etc.

GRNC (Groups Not Counted)

GRNC means, "The groups in this message have not been counted." GRNC is mandatory in the prefix in messages bearing an accounting symbol when groups are not counted. An accounting symbol is used to affix financial responsibility when charges are incurred. Accounting symbols are discussed in detail in the applicable edition of NTP 9.

HM (Emergency Silence Sign)

Emergency silence may be imposed or lifted by a station only when authorized by competent authority. HM, transmitted three times, means "Cease transmissions immediately; silence will be maintained until directed to resume."

The silence transmission HM HM HM after a call means "Station(s) addressed cease all transmissions on this net immediately." After a call HM HM HM followed by a frequency or frequency designator means "Station(s) addressed cease all transmission immediately on that frequency or that indicated by a frequency designator."

Emergency silence is lifted by addressing the station(s) concerned and transmitting the operating signal meaning "Negative" (ZUG) followed by HM HM HM.

T (Transmit To)

T, when used, appears in the transmission instructions. T alone means, "Station called transmit this message to all addressees in the address component." For example:

(5SP) (2CR) (LF)

NOKB DE NFSK (2CR) (LF)

T (2CR) (LF)

P 221405Z NOV 76 (2CR) (LF)

(Rest of message) (2CR) (8LF)
(4Ns) (12LTRS)

In the preceding example, the placement of T in the transmission instructions tells NOKB to transmit the message to all addees in the address component.

T, followed by an address designation(s), means "Station called transmit this message to the addressee(s) whose address designation(s) follow." For example:

(5SP) (2CR) (LF)

NOKB DE NFSK (2CR) (LF)

T NNBD (2CR) (LF)

P 221410Z NOV 76 (2CR) (LF)

(Rest of message) (2CR) (8LF)
(4Ns) (12LTRS)

In the preceding example, NFSK is telling NOKB to transmit the message to NNBD.

T, preceded by a call sign and followed by an address designation(s), means "Station whose call sign precedes T transmit this message to the addressee(s) whose address designation(s) follow T." For example:

(5SP) (2CR) (LF)

NOKB NNBD DE NFSK (2CR) (LF)

NNBD T NDRS (2CR) (LF)

NOKB T NRMC (2CR) (LF)

P 221430Z NOV 76 (2CR) (LF)

(Rest of message) (2CR) (8LF)
(4Ns) (12LTRS)

In the preceding example, NNBD and NOKB are to transmit the message to NDRS and NRMC, respectively. It should be noted that when more than one station is called and directed to relay a message, the transmission instructions for each such station must appear on a separate line.

T instructions may be modified by use of the operating signal ZWL to denote that no forwarding action is required to the addressee designation(s) which immediately follow ZWL. For example:

(5SP) (2CR) (LF)

NOKB DE NFSK (2CR) (LF)

T ZWL NDRS (2CR) (LF)

P 221445Z NOV 76 (2CR) (LF)

FM NFSK (2CR) (LF)

TO NRMC (2CR) (LF)

NMFO (2CR) (LF)

NDRS (2CR) (LF)

NBIB (2CR) (LF)

(Rest of message) (2CR) (8LF)
(4Ns) (12LTRS)

In the preceding example, NFSK has directed NOKB to relay the message to all of the addees except NDRS by using the operating signal ZWL after T and preceding the call sign to be exempted.

There are many uses of the various operating signals and prosigns, and it would be difficult to foresee each circumstance in which they would be used. A thorough understanding of the basic rules regarding the use of these prosigns and operating signals is essential to TTY operators, and, of course, nothing can teach proper usage as experience can. It is recommended to all potential operators that they thoroughly read and understand the applicable edition of ACP 126 as well as the applicable procedures outlined in Fleet and Force Commanders' directives.

MANUAL SWITCHING SYSTEMS

The difference in switchboard and TTY equipment used by the various nations precludes a combined manual switching procedure. The manual switching procedures used by each nation are contained in the National Annex to the applicable edition of ACP 126. For combined working, local arrangements must be made for all stations to use the applicable calling and operating procedure prescribed by the nation to whose switchboard they are connected.

There are several special abbreviations that should be understood by TTY operators who are part of a manual switching system. They are as follows:

(1) BKD (Booked) - "Your call has been booked." Used by switchboards after BOOK has been requested.

(2) BOOK - "It is requested that this call be booked." The precedence of the message awaiting transmission should be included in the book request.

(3) ENGD (Engaged) - "The station called is engaged." If the called station is engaged, the calling station may then transmit BOOK, followed by the precedence of the message awaiting transmission.

(4) OOO ("Out of Order") - "The circuit(s) to the station called is out of order."

Manual switching systems are engineered in such a manner that each station connected to a switching central switchboard can communicate with other stations connected to the same switchboard by manual cross connection or patching. Although establishing communication and making and terminating connections require a different procedure than that required for other methods of manual TTY operation, the procedure for handling messages through switching centrals is the same as in other methods of manual TTY operation. Exceptions to this are explained in the National Annex to the applicable edition of ACP 126.

Placing Calls

A station operator calls the switchboard operator by depressing the "BREAK" switch for two seconds. When the answer is received from the switchboard operator, the originating station transmits a preliminary call indicating the station(s) with which communication is desired. This call consists of the identification of the called station(s), the prosign DE, the identification of the station initiating the call, the precedence prosign, and the prosign K. If the precedence is FLASH, five bells will be sounded after the prosign K.

After the switchboard operator has completed the connection between the calling and called station(s), repeated the preliminary call, and an answer has been received by the station initiating the call, transmission of traffic will begin. Traffic is transmitted in the same manner as if there were no switchboards involved.

Recalling And Disconnection

During a connection, the switchboard operator may be recalled by depressing the break switch for two seconds. When an answer is received from the switchboard, the recalling station should immediately transmit the reason for the recall.

When the station which initiated the call is ready to terminate the connection, the station recalls the switchboard by transmitting a two second break. To terminate the connection, the calling station transmits the prosign DE, the station identification, and the prosign AR.

Occasionally, switching arrangements cannot be made through existing trunk connections or are not considered practicable for further switching. In this event, the message(s) are "TABLED OUT", i.e. passed to a local reperforator or teletypewriter for onward transmission in the procedure applicable to that part of the network.

CHAPTER 14

AUTOMATED SYSTEMS

Through modern technology, telecommunications capabilities have been improved in many areas. For example, we now have more efficient modulation techniques and transmission methods, better error detection and correction coding, and satellite relay. Thus, the quality and speed of communications have been greatly improved in addition to increasing information transfer capabilities.

In the past, manual logging, reproduction, distribution, filing, readdressal, etc., resulted in system "bottlenecks." These bottlenecks still exist in some areas of the Naval Telecommunications System (NTS) and prevent the realization of acceptable writer-to-reader times. It is through the automation of these functions that we are now pursuing acceptable communications in a modern dynamic environment. This chapter covers basic information concerning major automated systems that are in use today.

AUTODIN

The Automatic Digital Network (AUTODIN) is a worldwide, computerized, general purpose, communications system. AUTODIN provides for the transmission of both narrative and data pattern traffic on a store-and-forward basis. The objective of AUTODIN is to provide reliable, secure, and efficient communications, incorporating error detection and the highest speed transmission equipment available. As part of the Defense Communications System (DCS), AUTODIN is managed by the Defense Communications Agency (DCA).

As a digital network, AUTODIN consists of switching centers that are interconnected by trunk lines. Each center has local lines that radiate from it to each subscriber terminal. Messages originating at any of the subscriber terminals are forwarded through their switching centers. The function of the message switching center is to accept messages from any of the subscribers, determine their classifications and precedences, and relay the messages to the addressed subscribers.

In addition to its reliability, AUTODIN is flexible. Appropriate interface equipments translate all inputs into a common machine language. AUTODIN is compatible with many different computer codes, speeds, and media (card, tape, etc.). Thus, communications equipment within the NTS can be integrated into the AUTODIN system.

AUTODIN SWITCHING CENTERS (ASCs)

The AUTODIN Switching Centers (ASCs) are the focal points of the entire network. The network proper is comprised of two interconnected portions: CONUS AUTODIN and Overseas AUTODIN. Within CONUS, the ASCs use leased or contract furnished equipment, whereas the Overseas ASCs use government-furnished equipment.

Input and output devices provide the central AUTODIN computer with the facilities necessary for communicating with the users. Input devices such as card readers and teletypewriters supply the computer with the data and instructions, while output devices provide the means for changing the data processed by the computer into a form specified by or intelligible to the users. The selection of input/output devices depends on the specific use for which a computer is intended.

Generally, input/output devices must meet two basic requirements. First, the devices must be able to modify all data so that it is acceptable to the computer during the input phase of the operation and must be able to present data in usable form during the output phase. Second, the devices must operate quickly and efficiently in conjunction with the computer. Because the various input/output devices use code language, it is necessary that you understand the basic languages used. They are as follows:

1. Hollerith Code—Standard punch card language.
2. ASC II Code—American Standard Code information interchange, eight-level paper tape.
3. ITA #2 Code—American version of international TTY alphabet, five-level paper tape.

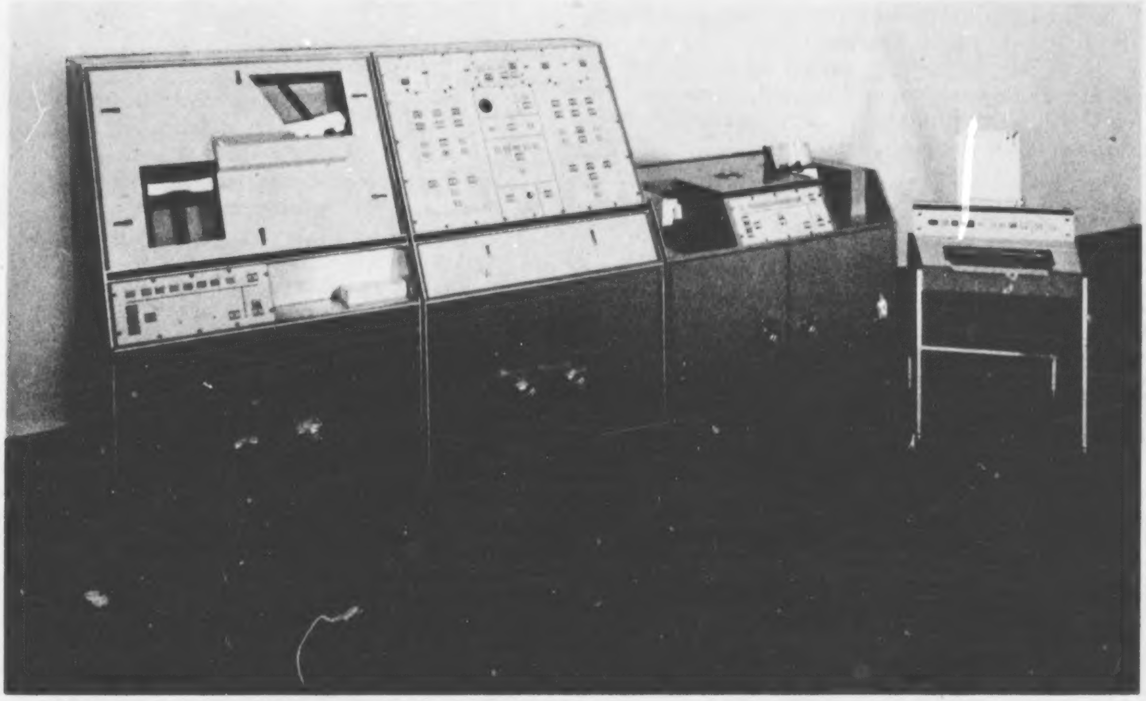
Operational Modes

The following five methods of channel operation are available in AUTODIN:

1. Mode I—A duplex operation with automatic error and channel controls allowing independent and simultaneous two-way operation.
2. Mode II—A duplex operation, normally associated with TTY equipments, allowing independent and simultaneous two-way operation. In this mode, there are no automatic error and channel controls.
3. Mode III—A duplex operation with automatic error and channel control but utilizing only one-way transmission. The return direction is used for error control and channel coordination.
4. Mode IV—Unidirectional operation (send only or receive only) without error control and channel coordination.
5. Mode V—A duplex operation, normally associated with TTY equipments, allowing independent and simultaneous two-way transmission. Message receipt is acknowledged through the use of control characters, and message accountability is maintained through the use of channel sequence numbers.

Programming

At the start of each AUTODIN message is a header containing pertinent information relating to the destination of the message. Messages can be sent to a single addressee or, if directed by the header information, copies can be sent to many addressees. This system saves time



128.2

Figure 14-1.—Low-speed card configuration.

and communication facilities, since only one message is prepared by the originator and sent to the switching center.

The timing system contained in AUTODIN equipment briefly connects a switching center to each terminal in turn. Computer memories act as reservoirs for the incoming messages of each subscriber terminal. The computer is programmed to connect each terminal in turn during a cycle. The computer can service low and high speed terminals as well as the trunk line (or lines) linking it to the other switching center. Messages which have been received in their entirety are scheduled for output to the addressee's channel when its turn arrives in the cycle.

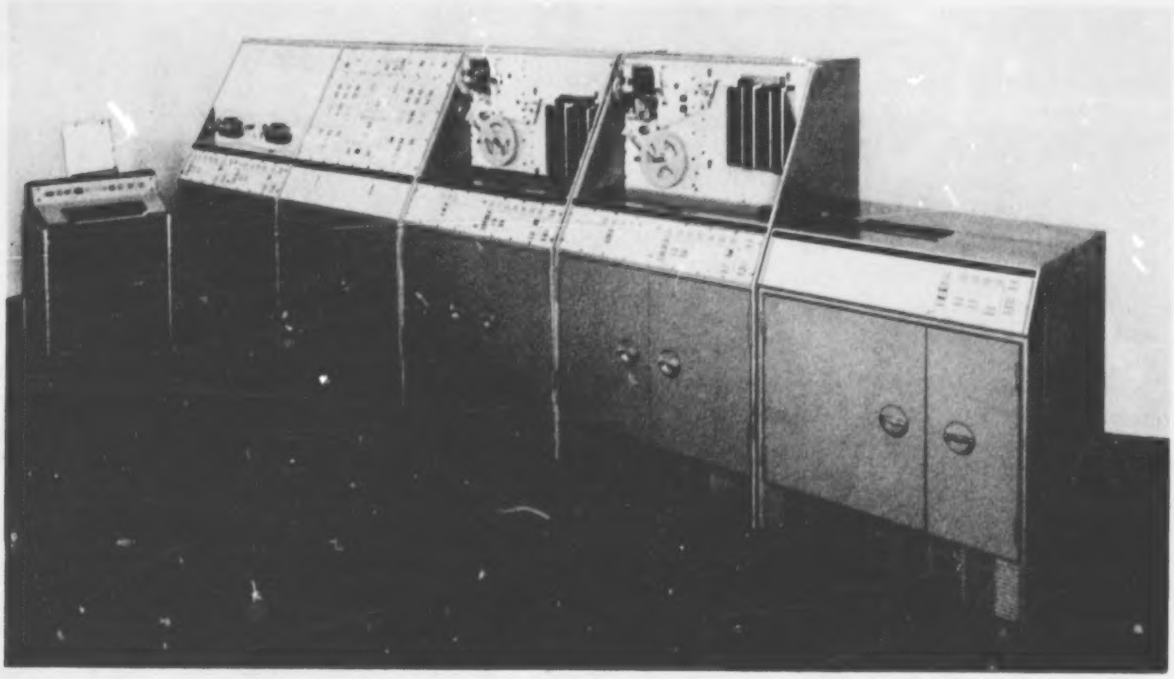
AUTODIN has built-in safeguards which detect almost any type of hardware or format error. Additionally, a complete (reference) copy of all messages that are relayed is kept on AUTODIN computer tape. A separate copy (called a "journal") is made of only the address. Using this journal copy as an index permits the system to locate the reference copy of any of the messages.

DIGITAL SUBSCRIBER TERMINAL EQUIPMENT (DSTE)

The most commonly used communications application of AUTODIN is in the form of Digital Subscriber Terminal Equipment (DSTE). The DSTE system is used in communications terminals around the world and may be configured in various forms. For example, the system may be configured as a card only terminal (figure 14-1), as a tape only terminal (figure 14-2), or as a combined card and tape terminal (figure 14-3).

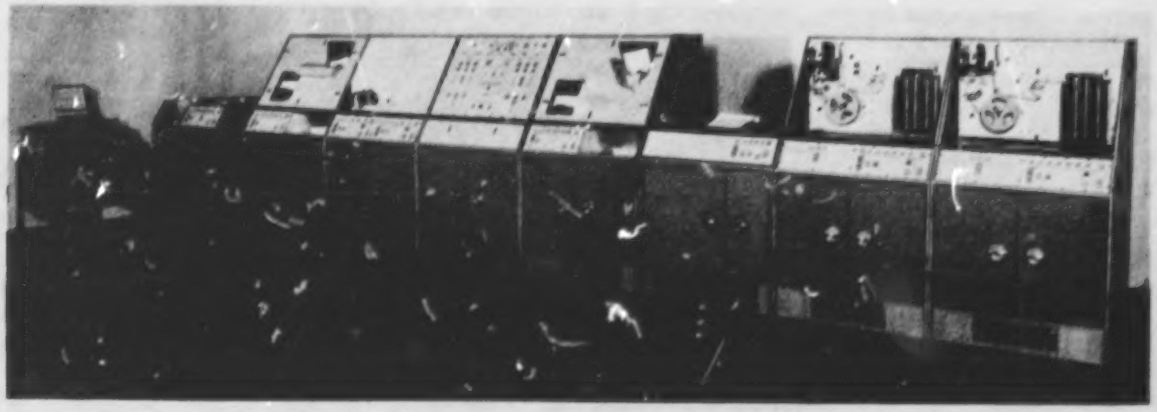
The various DSTE configurations are linked together by the ADMS. The ADMS are part of the AUTODIN switching centers as well as the subscriber terminals. Included in the DSTE are the following equipments:

- Common Control Unit



128.3

Figure 14-2.—High-speed paper tape terminal configuration.



128.4

Figure 14-3. — High-speed card and tape configuration.

- Card Reader
- Paper Tape Reader
- Low-Speed Card Punch
- High-Speed Card Punch
- Universal Keyboard
- Page Printer
- High-Speed and Low-Speed Paper Tape Punches

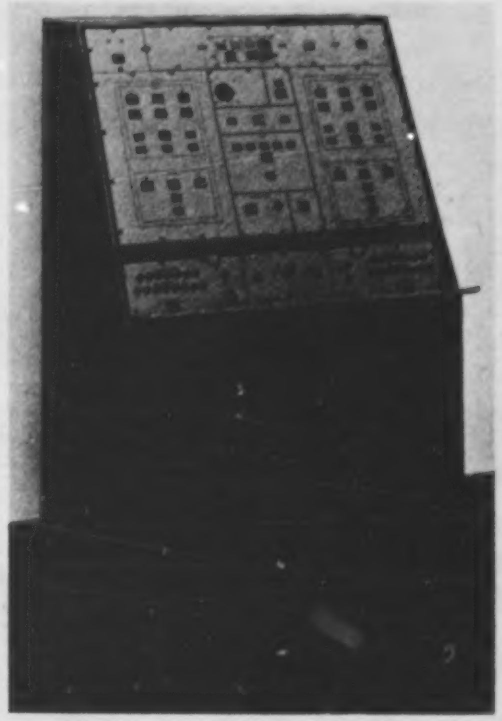
Common Control Unit (CCU)

The common control unit is the prime control device in each digital terminal. (See figure 14-4.) This unit automatically coordinates and interconnects full-duplex message traffic. The basic sending operation consists of the following:

1. Accepting data characters from tape or card readers;

2. Accumulating the input characters into data blocks in the CCU memory;

3. Distributing data blocks to an output tape or card device on a character basis.



128.5

Figure 14-4. — Common control unit.

Card Reader

The card reader (see figure 14-5) is a message input device for the transmit operation of the DSTE. The flow of intelligence is as follows:

1. Messages punched in cards in Hollerith code are read by the card reader.

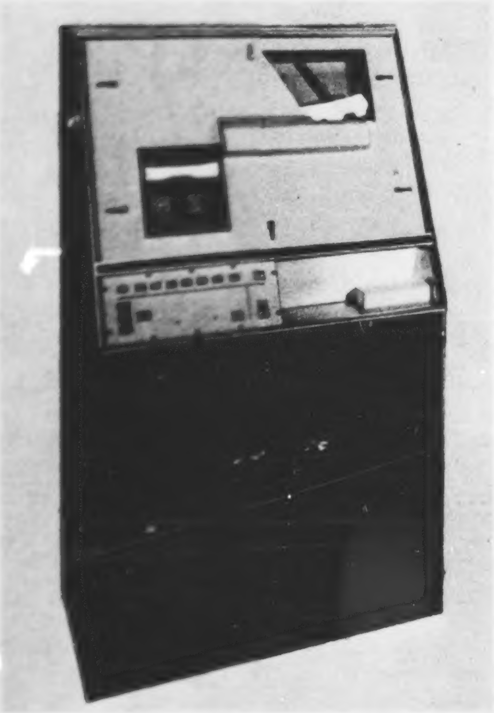
2. The Hollerith characters are electronically converted into ASC II characters.

3. The ASC II characters are transferred to the common control unit.

4. The common control unit accumulates the characters into blocks and sends them to the line for transmission. NOTE: The card reader can read cards and transfer data to the common control unit at a rate up to 1500 words per minute.

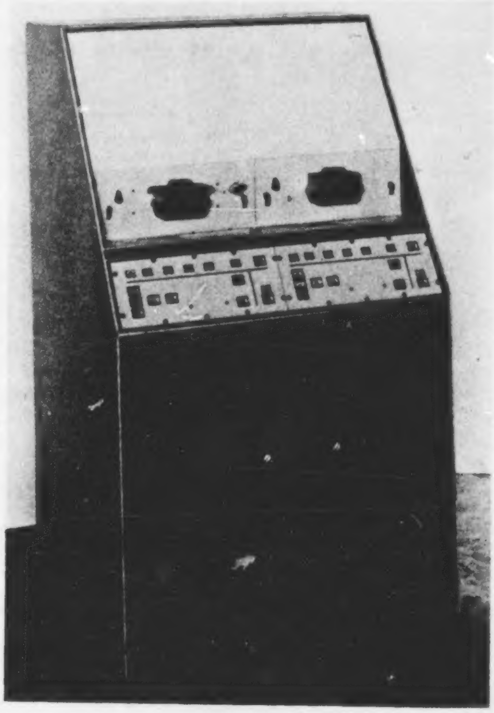
Paper Tape Reader

The paper tape reader (see figure 14-6) converts the perforations in punched paper tape to electrical data in the form of ASC II-coded characters and transfers this data to the common control unit. A front panel switch provides the option of reading data punched in either ASC II or ITA #2 code form. The data on ITA #2 coded tape is converted to the ASC II code form required as an input to the common control unit. The punched paper tape is stepped through the reader mechanism one character at a time in response to control signals received from the common control unit. The paper tape reader is capable of reading fully perforated paper tape and transferring the data at a rate of 1500 words per minute. A speed limiting switch permits reading chadless paper tape and transferring the data for any rate up to 187.5 words per minute.



128.6

Figure 14-5.—Card reader.



128.7

Figure 14-6.—Paper tape reader.

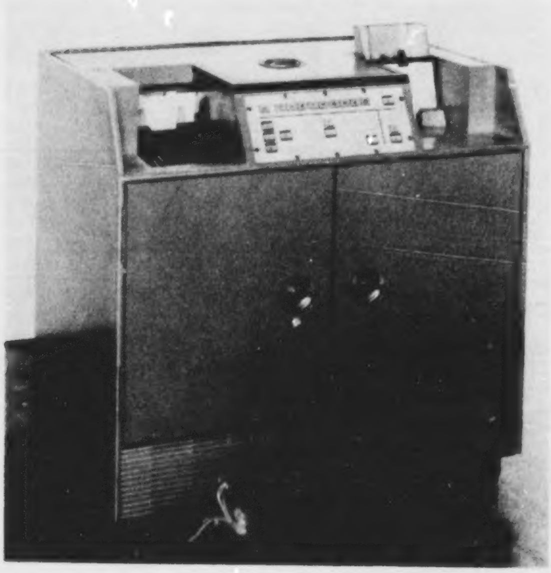
Low-Speed Card Punch

The low-speed card punch (see figure 14-7) can be used at a DSTE either as an on-line output device or off-line in conjunction with the universal keyboard (see figure 14-8).

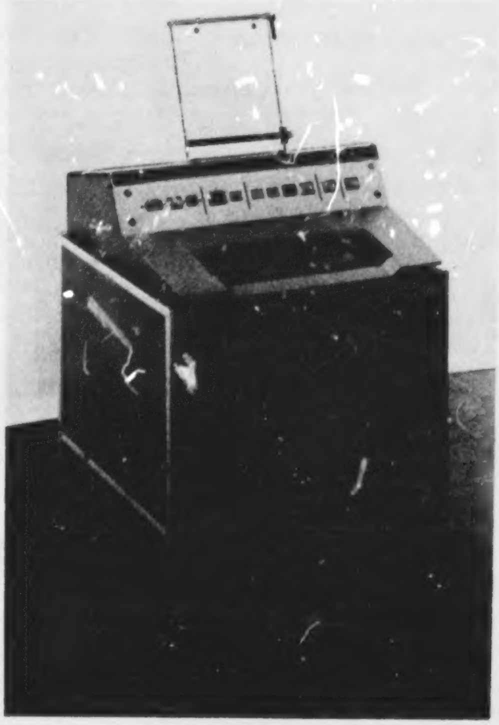
The low-speed punch card accepts data from the common control unit or keyboard in ASC II code. This data is converted to Hollerith code and punched in cards. The punch logic substitutes an asterisk for any character received in ASC II which does not have an assignment in Hollerith. The low-speed card punch can punch and print cards at any rate compatible with a common control unit rate up to 375 WPM (28 cards per minute).

High-Speed Card Punch

The high-speed card punch (see figure 14-9) accepts data from the common control unit in eight-level ASC II code. At the card punch, the data is then converted to Hollerith and punched in cards. The punch logic substitutes an asterisk for any character received in ASC II which does not have an assignment in Hollerith. The high-speed card punch supports speeds up to 1500 WPM or an equivalent of 150 characters per second (112 cards a minute).



128.8
Figure 14-7. -- Low-speed card punch.



128.10
Figure 14-8. — Universal keyboard.

Universal Keyboard

The universal keyboard (figure 14-8) is used in conjunction with a paper tape punch or a card punch. An off-line device, the keyboard affords the means to prepare messages for subsequent transmittal via the appropriate DSTE.

Page Printer

The page printer (figure 14-10) can be used in a digital terminal as an output monitor or as an input monitor.

As an output monitor, the page printer provides a printout of the data received at the

128.9

Figure 14-9.—High-speed punch.

128.12

Figure 14-10.—Page printer.

terminal. As an input monitor, the page printer provides hard copy of data transferred to the common control unit by the various DSTE readers. The assignment of a page printer to the input or output monitor is controlled at the common control unit.

The page printer operates at speeds up to 3000 WPM. Data is printed ten characters per inch, one to eighty characters per line, with six lines per inch. The printer can accommodate standard sprocket hole, single ply paper, multilith masters, ditto masters, and 2, 3, 4 and 5 multi-ply paper with carbons.

High- and Low-Speed Paper Tape Punches

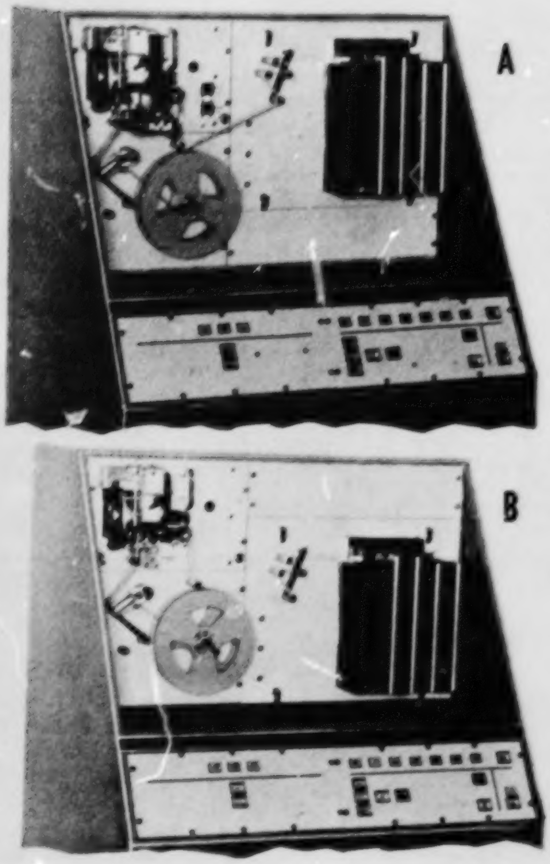
The high-speed and low-speed paper tape punches (see figure 14-11) function as on-line output devices. Both paper tape punches can also be used for off-line keypunch operation in conjunction with the universal keyboard.

As output devices, the paper tape punches accept ASC II coded data from the common control unit and enter this data onto punched paper tape in the form of either ASC II or ITA #2 coded characters. In addition, a printer-interpreter prints characters between the sprocket holes on the paper tape corresponding to the punched characters. The high-speed paper tape punch punches paper tape at speeds up to 1400 WPM. The low-speed paper tape punch punches and prints paper tape at speeds up to 18.75 characters per second and will punch, without printing, up to 75 characters per second.

A unique feature of the paper tape punches is the ability to operate the tape punch and printer interpreter independently. This permits off-line printing of previously prepared paper tape while the punch mechanism remains on-line.

Data communication does not necessarily solve all workload problems. Along with the obvious benefits, there are also drawbacks. Some disadvantages of the data processing communication systems are as follows:

1. Limited decision making capability of each piece of equipment.



128.13
Figure 14-11.—High-speed and low-speed paper tape punches.

2. Erroneous information is processed as rapidly as correct information, and errors are sometimes not as easily detected as with manual systems.

3. Exceptions to normal system programming are usually handled manually.

Message Types and Formats

The AUTODIN network will accept the following three types of messages:

1. Single Call—Destined for only one addressee or station.

2. Multiple Call—Destined for two or more addressees or stations which may be indicated as ACTION or INFORMATION.

3. General Messages—Messages which have a wide standard distribution and contain an identifying title and sequential number.

The AUTODIN system will accept and process plaindress, abbreviated plaindress, codress, and data pattern messages. Since all messages utilize the basic sixteen line format, the number of lines used is determined by the selected format. For example, format lines 6, 7, 8, and 9 are never shown externally in a codress message but are shown in plaindress format. Therefore, the communications need would dictate the type of format selected.

AUTODIN TELETYPEWRITER (TTY)

Much of the traffic that is passed within the AUTODIN system is accomplished via teletypewriter (TTY). You can consider AUTODIN to be an automatic tape relay system when communicating via TTY. When studying chapter 13 (Manual Teletypewriter Procedure), you learned that communications via TTY could be accomplished through the use of direct hard copy, tape copy, or a combination of both. The AUTODIN system is programmed to accept properly cut tapes, route them through the various switching centers and terminals en route to their ultimate destination, and produce a tape and hard copy to the designated addresses. However, there are requirements that must be met when headers and tapes are cut for transmission through AUTODIN. In this section, we will discuss some of the more important points concerning placement of elements, cutting of headers, security requirements, etc.

Routing Indicators

Within the AUTODIN network, a TTY tape is routed by means of a routing indicator. Routing indicators are combinations of not less than four or more than seven letters. A routing indicator begins with the letter "R" or "Q." The letter "R" indicates that the routing indicator is part of the world-wide tape relay system. The letter "Q" indicates that the routing indicator is within a self contained network within a command or theater.

The second letter of the routing indicator identifies the nation or international alliance to which the indicator belongs. For example, the letter "U," when used as the second letter, indicates the United States. The routing indicator used to denote that the tape is part of the worldwide network and is destined to a station in the United States, therefore, would begin with "RU."

The third letter identifies the geographical area in which a particular station is located or from which it is served. This is necessary for relay purposes because the second letter may indicate a large nation within which there are a number of subdivisions or stations. For example, many stations in the United States are designated by the third letter "C." Therefore, the first three letters of "RUC" would indicate that the tape is part of the worldwide network, destined to a certain geographical area within the United States. The fourth and subsequent letters of a routing indicator designate relay and tributary stations within the tape relay network. Like the first three letters, the fourth and subsequent ones may vary, depending upon location, area, etc.

Message Header

When a message tape is prepared for submission into the AUTODIN system, there are certain tape cutting procedures that must be adhered to, otherwise the message will be rejected by the ASC. The originating station is responsible for preparing the message for submission into the AUTODIN system. The Message Header (format line 2) is the starting point for the operator preparing the message tape. Modes I and III do not require format line 1. On terminals in which format line 1 is required (Modes II, IV, and V), the ASC validates these elements. The operator must remember when preparing the header that it must be letter perfect. The TTY message header is a basic 43 position header (see figure 14-12). The substance of each position on the header is as follows:

- Leader—To ensure acceptance and transmission of the first character of the message header, it is preceded by at least six blanks and six letters functions with five level baudot code (most common), or at least six nulls and six delete functions with ASC II (eight level baudot code).

- Position 1 (Precedence)—The prosign "Z" (FLASH), "O" (IMMEDIATE), "P" (PRIORITY), or "R" (ROUTINE) is placed here, depending upon the precedence assigned to the message. Additionally, the letter "Y" is designated for use on certain time-sensitive command and control emergency action messages. The letter "Y" indicates that a message has FLASH preemption capability and is designated Emergency Command Precedence (ECP). ECP traffic will be processed ahead of all other traffic and will interrupt lower precedence traffic already in processing within the AUTODIN system. Precedence is assigned by the originator and must not be altered by operating personnel.

- Positions 2 and 3 (Language and Media Format)—The language and media format (LMF) consists of two alphabetical characters. Position 2 of the header uses the character which indicates the method being used to insert the message into the AUTODIN system. For example, the character "A" is used if the device used for insertion is the ASC II (eight level baudot code) and the character "T" for the five level baudot code. The character in position 3 indicates the preferred output device of the addressee of the message.

- Position 4 (Classification)—The letters authorized for use to indicate degrees of classification in message headers are as follows:

A—Special Category (SPECAT)

T—Top Secret

S—Secret

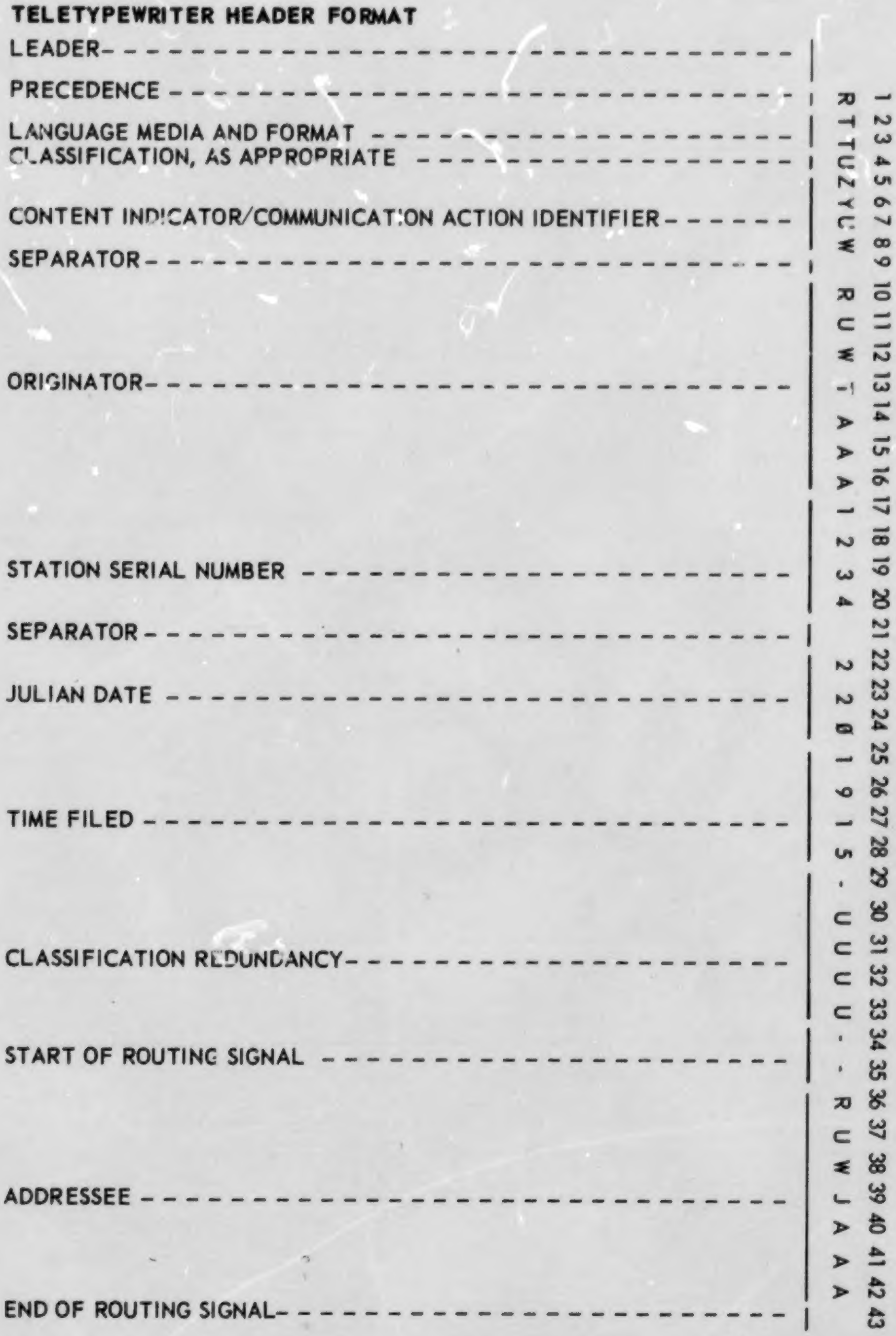
C—Confidential

E—Unclassified EFTO

U—Unclassified

- Positions 5 through 8 (Content Indicator/Communications Action Identifiers—These positions of the header are a combination of four letters or three letters and one number which are used to indicate message content and provide identification for communications handling. A complete listing of these codes is found in the applicable edition of JANAP 128.

- Position 9 (Separator)—At this point in the header, the operator is required to depress the space bar and insert the teletype code equivalent for space in this position on the message tape.


TELETYPEWRITER HEADER FORMAT
LEADER
PRECEDENCE
LANGUAGE MEDIA AND FORMAT
CLASSIFICATION, AS APPROPRIATE
CONTENT INDICATOR/COMMUNICATION ACTION IDENTIFIER
SEPARATOR
ORIGINATOR
STATION SERIAL NUMBER
SEPARATOR
JULIAN DATE
TIME FILED
CLASSIFICATION REDUNDANCY
START OF ROUTING SIGNAL
ADDRESSEE
END OF ROUTING SIGNAL
RTTUZYUW RUWTAAA1234 220915-UUUU--RUWJAAA
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43

76.65

Figure 14-12.—TTY message header (format line 2).

309

- Positions 10 through 16 (Routing Indicator)—The appropriate routing indicator of the originating station is placed in these positions.

- Positions 17 through 20 (Station Serial Number)—The station serial number (SSN) of the sending station is inserted here. The SSN serves two specific purposes. First, in combination with the originator's routing indicator, it provides positive identification for each transmission. Secondly, in the End of Message validation (EOM) discussed later in this section, the SSN appearing in format line 15 provides a means by which the ASCs can check for the existence of straggler messages. The SSN is expressed in four numeric characters beginning with 0001 and continuing consecutively through 9999. Upon completion of each series, a new series begins. Operating stations may use SSNs to identify local activities, channels, or positions within a station by assigning each desired activity a specific block of numbers. For example, one station may be assigned numbers from 0001 to 2000, the next station assigned numbers from 2001 to 4000, etc.

- Position 21 (Separator)—This position requires the same as Position 9.

- Positions 22 through 24 (Julian Date)—The Julian date is the date on which the message was received from the originator for transmission by the communications center. The first day of the calendar year is Julian 001, and each day is numbered consecutively thereafter.

- Positions 25 through 28 (Time Filed)—The time filed is the time (GMT) the message was received from the originator by the communications center for transmission. Each filing time must contain four numerical characters.

- Positions 29 through 33 (Classification Redundancy)—For security reasons, the classification designator used in Position 4 is repeated here. Position 29 is filled with a hyphen as a sentinel, and the classification designator in Position 4 is repeated in Positions 30 through 33.

- Position 34 (Start of Routing and Addressees)—The positions reserved for routing are comprised of two sections: The start of routing signal and the addressee routing indicators. The start of routing signal consists of two consecutive hyphens and will always precede the first addressee's routing indicator. Addressee routing indicators are listed immediately following the start of routing signal. A maximum of 500 routing indicators can be listed in these positions. If a message contains 501 or more routing indicators, thus requiring two separate transmissions, all routing indicators pertaining to a given four-letter routing indicator will be on one transmission.

- End of Routing Signal—The end of routing signal consists of a period (.) and is inserted in the position immediately following the last addressee's routing indicator.

- End of Message (EOM)—Consists of normal TTY ending procedure when five level baudot code is used (2CR, 8LF, 4Ns, 12LTRS). However, for ASC II, twelve delete functions are used (12DEL).

The message header must be accurately prepared. Back spacing, lettering out, double spacing, or using two or more FIGURES and LETTERS functions in sequence will cause the ASC to reject the message during attempted transmission from the originating station. It should also be noted that the EOM validation appearing in format line 15 and the EOM function in format line 16 must be prepared in uninterrupted sequence, letter perfect, and without correction.

General TTY Rules

When a TTY tape is cut for transmission, the message header should be preceded by at least six blanks and six letters (6BL, 6LTRS) with five level baudot code or by at least six nulls and six delete (6NULL, 6DEL) functions with ASC II code (eight level). This ensures acceptance and transmission of the first character of the message header.

When it is determined that a message must be commercially refiled, all colon (:) symbols appearing in the message text must be converted to the abbreviation "CLN" by the originating station's communications personnel.

Messages assigned a dual precedence will indicate the higher precedence in format line 2 and both precedences in format line 5. When a dual precedence of ECP or FLASH and a lower precedence is assigned, the originating station must make separate transmissions. One transmission is to the station serving the ACTION addressee(s) with the ECP or FLASH precedence in format line 2. The other is to the station(s) serving the information addressee(s) with the lower precedence in format line 5. Only one transmission should be made to a station serving both action and info addressees.

Bell signals are not inserted on ECP or FLASH messages because the ASC will generate bell signals automatically to Modes II, IV, and V tributary stations. Those stations operating in Modes I and III will receive a high precedence alarm. Mode V terminals may receive both the high precedence alarm and the bell signal.

Tributary stations must ensure that a record is made of the time of file (TOF) and the time available for delivery (TAD). These times are to be used when message processing times are determined.

TTY Message Lengths

To facilitate reproduction of incoming messages by distribution centers, all messages exceeding a total of 20 lines of heading and text are divided into pages for transmission, beginning with format line 5. The second and succeeding pages are identified by the page number, the routing indicator of the station of origin, and the station serial number, as discussed in chapter 13 (Manual Teletypewriter Procedure). For example:

PAGE 2 RUEDABA0123 (2CR 1LF)

The security classification is inserted after the page identification. The classification will have one space inserted separating each letter of the classification on all classified messages. "UNCLAS" will be placed in the page identification of unclassified messages, with no spaces separating the letters.

For example:

PAGE 2 RUEDABA0123 C O N F I D E N T I A L (2CR 1LF).

Whenever a TTY message exceeds five textual pages, the message text is divided into transmission sections at a convenient point for doing so. Each section is numbered, and the number is inserted in plain language at the beginning of the text following the classification or abbreviation UNCLAS.

In long encrypted messages, when a transmission section commences with a new cryptopart, the designation of the cryptopart follows the designation of the transmission section. Also, when a numerical group count is associated with an off-line encrypted message and indicated in format line 10, the count must indicate the number of groups in the text section being transmitted, not the number in the complete message. Cryptopart identification is included in the group count; the page identification and transmission section are not.

Statistical and meteorological messages are permitted one hundred (100) lines of text without paging whenever the inclusion of paging information would disrupt processing by the user. However, these types of messages should be divided into transmission sections if they exceed 100 lines of text.

Transmission Identification (TI)

As a means of maintaining traffic continuity, TTY terminals (Modes II, IV, and V) will prefix each message header with a message transmission identification (TI). The transmission identification is constructed without spaces and must be accurately prepared without corrections. For example, a correctly prepared TI might appear as follows:

VZCZCJTA (FIGS) 123 (LTRS) (2CR 1LF)

The elements of the TI and their meanings are as follows:

1. V—Ensures that the first character of intelligence is not lost or garbled.
2. ZCZC—Indicates the start of the message.
3. JTA—Station/channel designator letters.
4. One FIGS shift.
5. 123—Three-digit number indicating the sequential number of transmissions.
6. LTR shift, two carriage returns, and one line feed.

The station/channel designators will vary for each channel and is determined by the status of the originating station. For example, if a minor relay or tributary station originates a TI to a major relay station, the first two characters consist of the fifth and sixth letters of the station routing indicator. The third character identifies the specific channel. Channel designators commence with the letter A, progressing alphabetically, and are assigned to all connected channels. For example, a tributary station having routing indicator RUWTABA will use the designator ABA for the first outgoing channel and ABB, ABC, etc., for each additional outgoing channel.

Security Warning

The security warning is provided as the first component of format line 4. The appropriate operating signal (ZNR or ZNY) is used, followed by a classification character repeated five times. The operating signal and classification characters are as follows:

1. ZNR UUUUU—For off-line encrypted messages and classified messages that are transmitted in the clear.

2. ZNY EEEEE—For unclassified EFTO messages.

3. ZNY, followed by CCCCC, SSSSS, or TTTTT—For Confidential, Secret, or Top Secret messages.

4. ZNY AAAAA—For Special Category (SPECAT) messages.

Misrouted And Missent Messages

A misrouted message is one which contains an incorrect routing instruction. This normally occurs when the originating communications center assigns incorrect routing indicators during message header preparation. Misrouted messages are usually not discovered until they reach the communications center of the called routing indicator. A tributary station in receipt of a misrouted message should take the following actions:

1. Obtaining the correct routing indicator, if possible.
2. Applying a header change to the misrouted message and retransmitting to the correct routing indicator.
3. Originating a service message to the originating station advising of the reroute action and correct routing indicator.

A missent message is one that contains a correct routing indicator but is transmitted to a station other than the one represented by the routing indicator. Missent messages may be caused by an equipment malfunction, incorrect switching, or operator error. A tributary station in receipt of a missent message should take the following actions:

1. Reintroducing the message into the AUTODIN system as a suspected duplicate (SUSDUPE) after applying a header change.

2. Forwarding a routing service message to the connected ASC citing the complete header, time of receipt, and advising that the message has been protected.

Suspected Duplicates

When a station has cause to suspect that a message may have been previously transmitted but definite proof of prior transmission cannot be readily determined, the message should be forwarded as a suspected duplicate by applying a header change. However, if a station receives a message that is already marked as a suspected duplicate, the station should file the message, if it was previously received and delivered to the addressee. If there is no indication that the message was previously received and delivered, the message should be forwarded.

Stations receiving unmarked duplicate transmissions should immediately forward a routine service message to the originating station, citing the complete header format of the duplicated message including the time of receipt of the original and duplicate transmissions. If the initial copy was delivered to the addressee, the station should file the message.

Upon receipt of service messages that concern duplicates, the originating station should take the following actions:

1. Check transmission records to determine the validity of the duplication report.
2. Ensure in-station procedures are adequate to guide operating personnel in the retransmission of messages that are suspected duplicates.
3. Have maintenance personnel accomplish equipment checks if equipment malfunction is suspected to be the cause of duplication.
4. Advise the connected ASC via routine service message if only one transmission can be accounted for.

An ASC receiving notification of duplicate transmission should search its records to determine if the message was received in duplicate. If the message was not received in duplicate, it must be traced on a station-to-station basis to determine the point of duplication.

AUTODIN DATA PATTERN MESSAGES

Data pattern messages consist of either 80-character record blocks (card messages) or images of the 80-character record blocks (magnetic tape messages). The normal data pattern message consists of format lines 2, 12, and 16 (header, text, and EOT). Data pattern messages transmitted via message switching facilities are limited to 500 cards. Additional cards are used as pilots which are accepted as exceptions to the maximum message length and will be accepted by the ASCs. Normally, messages containing more than 500 cards should be transmitted as two or more transmission sections and each section assigned a separate station serial number. The message header (format line 2) must be accurately prepared. If the header is inaccurate, the message will be rejected by the ASC.

The two forms that are most used in the AUTODIN data pattern system are the Data Message Form (DD Form 1392) shown in figure 14-13, and the Message Correction Notice (DD Form 1503) shown in figure 14-14. The data message form is designed to provide originators with information to prepare header cards for transmission. The message correction notice is designed to provide the communications facility with a means for notifying originators of message discrepancies.

Data Pattern LMF

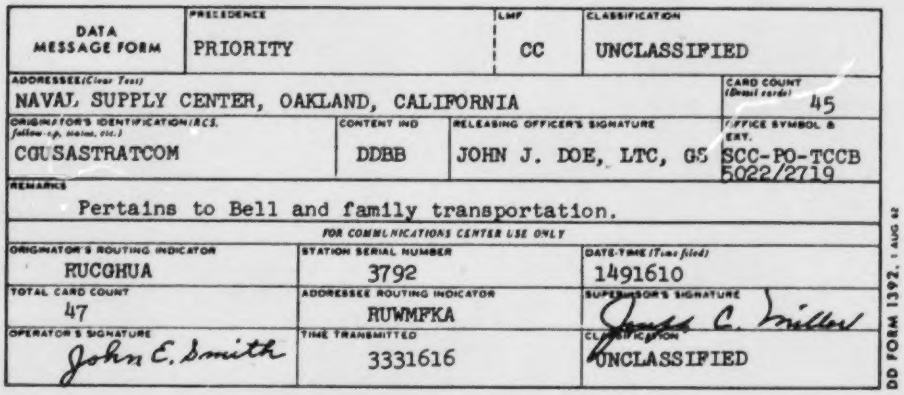
Earlier, we covered the preparation of messages for TTY communications. We noted the use of language and media format (LMF) designators in the message header. In data pattern message format, the most common LMF designator is CC (card to card). However, the following LMFs are available for use in data pattern message format:

CT (card to tape), CA (card to ASC II), TC (Tape to card), and AC (ASC II to card). For example, notice that the LMF in figure 14-13 is CC (card to card).

Originated Data Traffic

Message originators having automatic capabilities may deliver data pattern messages with prepared communication header, text, including complete text header information (format line 12), and EOT formats (format line 16) containing all the necessary information.

Station serial numbers (SSN) may be assigned on a preallocated basis. The Julian date and time entered in format line 2 should be within 30 minutes of the actual time that the message



DATA MESSAGE FORM	PRECEDENCE PRIORITY	LMF CC	CLASSIFICATION UNCLASSIFIED

ADDRESSEE (Clear Text): NAVAL SUPPLY CENTER, OAKLAND, CALIFORNIA

CARD COUNT (Detail cards): 45

ORIGINATOR'S IDENTIFICATION (RCS, follow-up, memo, etc.): CGUSASTRATCOM

CONTENT IND: DDBB

RELEASING OFFICER'S SIGNATURE: JOHN J. DOE, LTC, GS

OFFICE SYMBOL & EXT.: SCC-PO-TCCB 5022/2719

REMARKS: Pertains to Bell and family transportation.

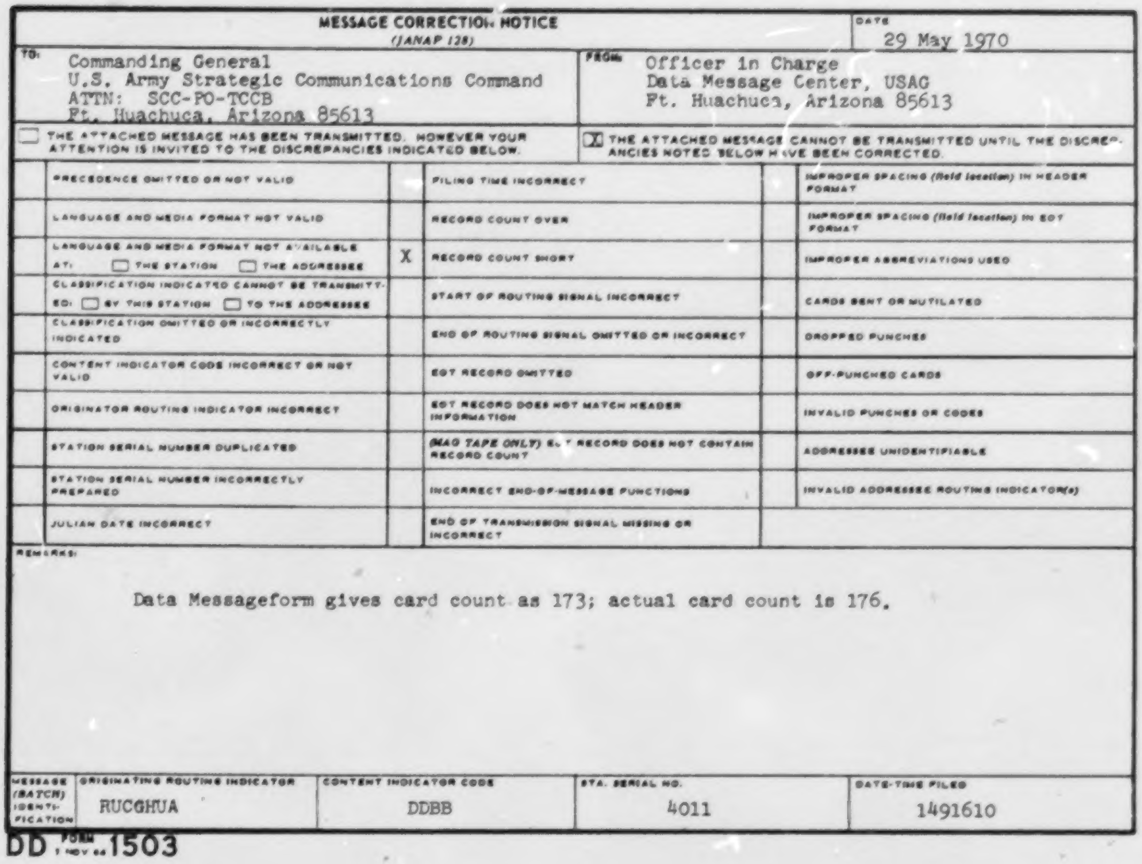
FOR COMMUNICATIONS CENTER USE ONLY

ORIGINATOR'S ROUTING INDICATOR RUCGHUA	STATION SERIAL NUMBER 3792	DATE-TIME (Time filed) 1491610
TOTAL CARD COUNT 47	ADDRESSEE ROUTING INDICATOR RUWMFKA	SUPERVISOR'S SIGNATURE Joseph C. Miller
OPERATOR'S SIGNATURE John E. Smith	TIME TRANSMITTED 3331616	CLASSIFICATION UNCLASSIFIED

DD FORM 1392, 1 AUG 62

76.69

Figure 14-13.—Data message form.



MESSAGE CORRECTION NOTICE
(JANAP 128)

DATE: 29 May 1970

TO:
Commanding General
U.S. Army Strategic Communications Command
ATTN: SCC-PO-TCCB
Ft. Huachuca, Arizona 85613

FROM:
Officer in Charge
Data Message Center, USAG
Ft. Huachuca, Arizona 85613

☐ THE ATTACHED MESSAGE HAS BEEN TRANSMITTED. HOWEVER YOUR ATTENTION IS INVITED TO THE DISCREPANCIES INDICATED BELOW.

☒ THE ATTACHED MESSAGE CANNOT BE TRANSMITTED UNTIL THE DISCREPANCIES NOTED BELOW HAVE BEEN CORRECTED.

	PRECEDENCE OMITTED OR NOT VALID		FILING TIME INCORRECT		IMPROPER SPACING *(field location)* IN HEADER FORMAT
	LANGUAGE AND MEDIA FORMAT NOT VALID		RECORD COUNT OVER		IMPROPER SPACING *(field location)* IN EOT FORMAT
	LANGUAGE AND MEDIA FORMAT NOT AVAILABLE AT: ☐ THE STATION ☐ THE ADDRESSEE	X	RECORD COUNT SHORT		IMPROPER ABBREVIATIONS USED
	CLASSIFICATION INDICATED CANNOT BE TRANSMITTED: ☐ BY THIS STATION ☐ TO THE ADDRESSEE		START OF ROUTING SIGNAL INCORRECT		CARDS BENT OR MUTILATED
	CLASSIFICATION OMITTED OR INCORRECTLY INDICATED		END OF ROUTING SIGNAL OMITTED OR INCORRECT		DROPPED PUNCHES
	CONTENT INDICATOR CODE INCORRECT OR NOT VALID		EOT RECORD OMITTED		OFF-PUNCHED CARDS
	ORIGINATOR ROUTING INDICATOR INCORRECT		EOT RECORD DOES NOT MATCH HEADER INFORMATION		INVALID PUNCHES OR CODES
	STATION SERIAL NUMBER DUPLICATED		*(MAG TAPE ONLY)* EOT RECORD DOES NOT CONTAIN RECORD COUNT		ADDRESSEE UNIDENTIFIABLE
	STATION SERIAL NUMBER INCORRECTLY PREPARED		INCORRECT END-OF-MESSAGE FUNCTIONS		INVALID ADDRESSEE ROUTING INDICATOR(s)
	JULIAN DATE INCORRECT		END OF TRANSMISSION SIGNAL MISSING OR INCORRECT		

REMARKS:

Data Messageform gives card count as 173; actual card count is 176.

MESSAGE (BATCH) IDENTIFICATION	ORIGINATING ROUTING INDICATOR	CONTENT INDICATOR CODE	STA. SERIAL NO.	DATE-TIME FILED
	RUCGHUA	DDBB	4011	1491610

DD FORM 1 NOV 64 1503

76.68

Figure 14-14. — Message correction Notice.

is delivered to the communications facility. If messages are not received by the communications facility within the prescribed 30 minutes, they should be corrected by the communications center personnel, and the originator should be advised via the Message Correction Notice (DD Form 1503), shown in figure 14-14.

Originating stations may identify local activities, channels, or positions within a station by assigning blocks of SSNs to the activities concerned. Blocks of SSNs must contain sufficient numbers to preclude the reuse within one week of normal message activity. SSNs assigned in blocks should be assigned consecutively. When the entire block has been used, the numbers should be repeated beginning with the first SSN of the block.

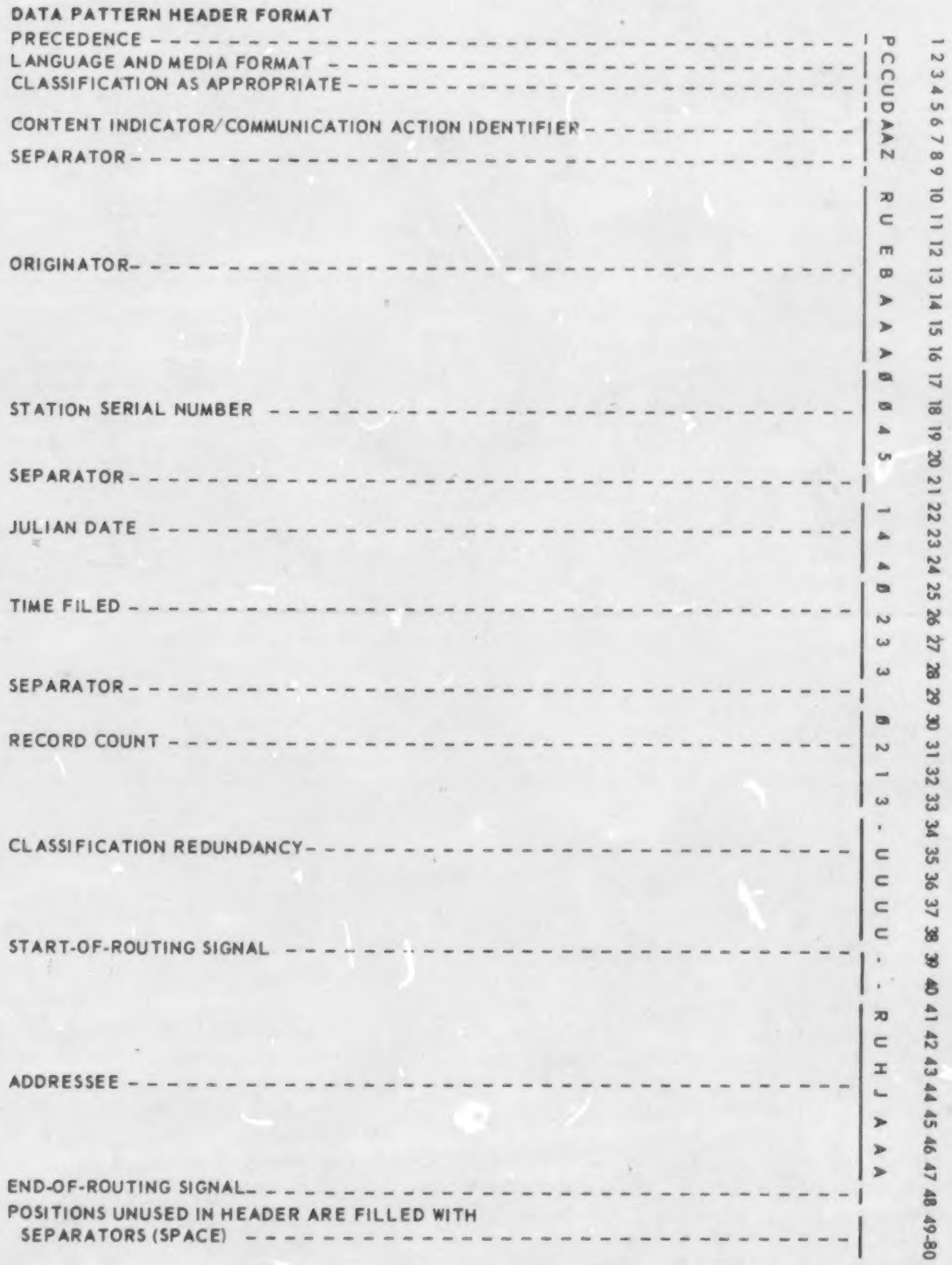
Preparation of Data Pattern Headers

Because ASC functions depend on the correct sequence of characters and elements comprising the header and EOT format, the accurate preparation of these characters and elements is mandatory.

The following is a discussion of proper header format which is shown in figure 14-15:

- Position 1 (precedence) — The following prosigns are used in Position 1:

Z — FLASH
O — IMMEDIATE
P — PRIORITY
R — ROUTINE


DATA PATTERN HEADER FORMAT
PRECEDENCE
LANGUAGE AND MEDIA FORMAT
CLASSIFICATION AS APPROPRIATE
CONTENT INDICATOR/COMMUNICATION ACTION IDENTIFIER
SEPARATOR
ORIGINATOR
STATION SERIAL NUMBER
SEPARATOR
JULIAN DATE
TIME FILED
SEPARATOR
RECORD COUNT
CLASSIFICATION REDUNDANCY
START-OF-ROUTING SIGNAL
ADDRESSEE
END-OF-ROUTING SIGNAL
POSITIONS UNUSED IN HEADER ARE FILLED WITH SEPARATORS (SPACE)
PCCUDAAZ RUEBAAA0 045 1440233 0213-UUUU--RUHJAAA
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49-80

76.70

Figure 14-15.—Data pattern message header.

315

NOTE: The flash preemption capability, designated ECP, of the AUTODIN system is not applicable to data pattern messages.

- Positions 2 and 3 (Language and Media Format)—Two alphabetical characters that can be derived from the current edition of JANAP 128.

- Position 4 (Classification)—The following is a list of authorized classification indicators:

A—Special Category (SPECAT)
T—Top Secret
S—Secret
C—Confidential
R—Restricted (not authorized for U.S. use)
E—Unclassified EFTO
U—Unclassified

- Positions 5 through 8 (Content Indicator/Communication Action Identifier)—Consists of four alphabetical characters or three alphabetical characters and one numerical character. The authorized combinations are found in the current edition of JANAP 128.

- Position 9 (Separator)—A space is left in this position.

- Positions 10 through 16 (Originator)—The appropriate routing indicator of the originating station is placed in these positions. This field must contain seven characters.

- Positions 17 through 20 (SSN)—SSNs provide positive identification of the message as well as provide a means for ASCs to check for stragglers. SSNs are expressed in four numeric characters beginning with 0001 and continuing consecutively through 9999. Upon completion of each series of 9999 numbers, a new series begins.

- Position 21 (Separator)—A space is left in this position.

- Positions 22 through 24 (Date)—Julian date, beginning with 001, is placed in these three positions.

- Positions 25 through 28 (Time Filed)—Four numerical characters indicating the GMT that the message was received from the originator by the communications center.

- Position 29 (Separator)—A space is left in this position.

- Positions 30 through 33 (Record Count)—The record count is the total number of 80-character records in the data message, including header and EOT records.

- Positions 34 through 38 (Classification Redundancy)—Position 34 is filled with a hyphen as a sentinel, and the classification designator used in Position 4 is repeated in Positions 35 through 38.

- Positions 39 through 80, as required—the positions reserved for routing are comprised of two sections: The start of routing signal and the addressee routing indicators.

- Start of routing signal—The start of routing signal consists of two consecutive hyphens and will always precede the first addressee's routing indicator. Addressee routing indicators are listed immediately following the start of routing signal. A maximum of 500 routing indicators can be listed in these positions. If a message contains 501 or more routing indicators, thus requiring two separate transmissions, all routing indicators pertaining to a given four-letter routing indicator will be on one transmission. The first addressee station is identified beginning in Position 41; additional addressees are contained in subsequent positions, separated by a space.

- End of Routing Signal—The end of routing signal consists of a period (.) and is inserted in the position immediately following the last addressee's routing indicator. Unused portions in the data pattern header are filled with spaces.

- End of Transmission (EOT) Format—The final record of a data pattern message is used to identify the originating station and other associated transmission information to the addressee after the header (format line 2) is stripped from the message by the communications facility. The EOT is an 80-position record. The EOT consists of a repeat of all header information starting with the precedence, including all intervening elements, and ending with the character before the start of routing signal. The appropriate end of transmission (EOT) signals are as follows:

1. In a multiple record transmission (three or more cards), the EOT consists of the letter N repeated four times, (see figure 14-16) in positions 77 through 80 of the EOT record.

316

Precedence	1	P
Language and Media Format	2 3	C C
Classification, as appropriate	4	U
Content Indicator/Communication Action Identifier	5 6 7 8	D A Z Z
Separator	9	
Originator	10 11 12 13 14 15 16	R U E B A A A
Station Serial Number	17 18 19 20	0 0 4 5
Separator	21	
Julian Date	22 23 24	1 4 4
Time Filed	25 26 27 28	0 2 3 3
Separator	29	
Record Count	30 31 32 33	0 2 1 3
Classification Redundancy	34 35 36 37 38	- U U U U
Separators	39-76	
End-of-Transmission Signal	77-80	NNNN

76,142

Figure 14-16.—EOT record format.

2. The EOT used in a single-record message is a single letter N appearing in the 80th position of the card.

Data Message Retention

Each data pattern message (including complete header and text) is maintained intact for a period of at least 10 days. When storage space or other operating considerations preclude compliance with the 10 day retention period, exceptions are granted on an individual basis in accordance with the rules set forth in the current edition of JANAP 128.

After the mandatory retention period, the header and text may be separated. The text may be destroyed or diverted to other uses as dictated by local policy. The header is retained for a period of not less than 30 days as a communications record. Header and text information will be retained beyond the specified retention periods for the completion of tracer or other investigative actions.

Message Batching

Message batching, or commingling, is defined as the storing of a number of data pattern messages destined for one geographical location and the forwarding of these messages as one transmission, with one header card and one EOT card. Message batching may be used as a method of increasing operating efficiency and avoiding retransmission of large groups of cards, or records, in accordance with the following provisions:

1. The messages are addressed to addressees who by prearrangement have agreed to accept responsibility for separating and/or distributing the records to the activities of primary interest.

2. The batched messages are assigned only one classification equal to that of the highest classified material included.

3. No more than 500 cards or records are included in each transmission section.

4. A single, general purpose content indicator code (CIC) is assigned that will accommodate the general subject matter of the batched transmission.

Received Data Traffic

Upon receiving data pattern traffic, communications personnel endorse the header card to indicate the time of receipt (TOR). TOR is defined as the time of receipt of the EOT record. Those terminals that are automated and receive printed journal entries indicating TOR of the message are exempt from this requirement. After endorsing the card with the TOR, the message record count should be verified. If the record count is incorrect, a retransmission should be requested from the originating station. Those messages bearing incorrect card counts are forwarded to the addressee "subject to correction" and the addressee advised of the discrepancy. Lastly, the header card is removed and filed as a communications record for a period of at least 30 days. Complete filing and record information is found in the current edition of JANAP 128.

MAGNETIC TAPE MESSAGES

Magnetic tape is one of the principal media used in Electronic Data Processing Equipments (EDPE). Magnetic Tape Terminal Stations (MTTS) in the AUTODIN provide for rapid exchange of large volumes of data in a relatively short period of time. Terminals in CONUS, which have compatible equipment and circuit speeds and are connected to the same ASC, may communicate directly via HARPS (Hybrid AUTODIN Red Patch Service). HARPS provides a direct, subscriber to subscriber, encrypted circuit. It uses the same circuit and equipment normally used in the message switching component of the network. Generally, the operating speed under a HARPS configuration is 400 cpm (cards per minute) while normal message switching operating speed may be 200 or 100 cpm. Those not serviced via HARPS communicate via normal message switching which automatically performs the necessary speed, format, and code conversions. The basic mode of MTTS operation with other AUTODIN tributary stations is either full duplex or store and forward.

Operating Rules

All received tape reels must be periodically dismounted and made available for delivery as scheduled by the receiving activity and system manager. A magnetic tape reel accepted by the communications facility for transmission is screened and arranged for transmission according to majority message precedence levels contained on the reel. Establishment of transmission schedules is the responsibility of the commands concerned and prior coordination must be effected to provide for efficient use of the equipment and circuit time. Schedules are limited to 30 minutes per period. Most facilities establish their own procedures for maintaining reel accountability and ensuring that message transmission has been effected. Message header and EOT printouts are furnished by the message originator with each reel of tape to be transmitted. If a message cannot be transmitted, the MTTS operator returns the reel to the originator, identifying the message (or messages) that could not be sent and giving the reason for the nontransmission, if known. Terminal equipment should not be used to change message media format for customer convenience—for example, changing from magnetic tape to card or narrative records.

Operating Precautions

Communications station master records, such as history tapes and journal records, will remain within the communications facility until destroyed. History tapes will be appropriately labeled to preclude the possibility of their being inadvertently delivered to addressees along with live traffic tapes.

Recorded information is very close to the edge of the tape. Tape edge indentations caused by careless tape handling will seriously affect the accuracy of magnetic tape recordings. It should also be noted that tape splices are not permitted in reels of tape used for traffic.

Message Formats

Message formats used within the AUTODIN require that each message contain a message heading, text, and EOT record. The text material on magnetic tapes may consist of a wide variety of information recorded in either structured or nonstructured formats depending upon the type of associated EDPE system. EOT is either a single N or four consecutive Ns as has already been discussed. The header, text, and EOT cards of magnetic tape messages are always transmitted in the AUTODIN common language code (ASC II). This is accomplished by automatic code conversion logic provided in the magnetic tape terminal.

The text of magnetic tape messages may be prepared by the EDPE system in 80-character data card images, series record images, or variable length record images. The length of data records to be transmitted via AUTODIN may vary according to user requirements. For general transmission of data throughout the system, computerized terminals must have the capability of transmitting records containing a minimum of 18 characters and a maximum of 1200 characters. Those subscribers desiring to transmit messages containing record length of less than 18 or more than 1200 characters must ensure that the addressee is capable of receiving such records prior to transmission. Typical line formats of magnetic tape message records are described in the current edition of JANAP 128.

Magnetic tape messages prepared for transmission are limited to a maximum of 40,000 characters (500 80-character data records) which include the header, text, and EOT records. The preparation of magnetic tape messages, formats, routing, contents, and sequence on tape is the responsibility of the message originator.

Message and Tape Reel Accountability

Each reel of tape presented to the MTTS operator for transmission will bear a tape label containing the following information:

1. Reel number.
2. Number of messages recorded on tape.
3. Highest precedence used.
4. Highest security classification.
5. Date and time filed.
6. Tape density.
7. LMF used.
8. Beginning and ending SSNs.
9. Time delivered to MTTS operator.

Each blank reel of tape furnished the MTTS operator for mounting on the receive tape transport should bear a tape label on which the following information should be recorded in the sequence of handling:

1. A statement that the reel is blank.
2. Reel number.
3. Highest classification ever recorded.
4. Time the reel is mounted on the receive transport.
5. Time the reel is removed from the receive transport.

6. Time the reel is delivered to the addressee.
7. Number of messages on the reel, type of messages, etc., if known.

All originated tape reels should be retained for not less than 10 days. The originated tape reel must be available to furnish retransmission or resubmission of service requests. The header and EOT printouts furnished the MTTS operator for both originated and terminated traffic should be maintained as a station communications record for not less than 30 days. Other logs recommended for MTTS operation are the Master Station Log and the Reel Delivery Log.

The Master Station Log reflects the current operation status of the terminal equipments and circuits and should also reflect equipment/circuit outages, their causes, and the corrective actions initiated.

The Reel Delivery Log should indicate the reel number and the time delivered to the transmitting operator or the addressee.

AUTODIN SECURITY

Required security protection should be afforded all classified traffic transmitted through the AUTODIN. As each message is transmitted by the originating station, the ASC automatically checks and compares the security classification stated in the header of the message against the authorized security level of the incoming circuit. Transmission of a message with higher security level than authorized will result in the message being rejected by the ASC. In addition, an automatic system-generated service will be transmitted by the ASC to the routing indicator contained in the originating station routing indicator field of the incoming message. The service will advise the originating station of the possible security compromise. Also, the ASC automatically checks and compares the security classification contained in the header of each message against the security classification of each destination. A security mismatch will occur for each destination that does not possess the necessary security level, and the ASC takes the following action:

1. In a single-address message, the ASC rejects the message; alarms will appear at the originating terminal indicating that the message needs retransmission.

2. In a multiple-address message with at least one deliverable destination, the ASC accepts the message and delivers it to all valid destinations. For invalid routing indicators, an automatically generated service is transmitted to the originating routing indicator advising that the message needs retransmission.

In-station operating procedures should be carefully composed and rigidly enforced to preclude inadvertent transmission of classified messages to stations or agencies not connected by properly secured circuits or not approved for the security classifications and any special category or special handling designations of the message involved. Complete security precautions and operating rules are contained in the current edition of JANAP 128.

AUTOVON

The Defense Communications System (DCS) Automatic Voice Network (AUTOVON) is a direct interconnected network between most military and other Government installations. The network includes activities in the continental United States and many overseas areas. AUTOVON phone calls may be made either by direct dialing or through a local operator, depending on what type of service is available. Once an installation is completed in the AUTOVON system, it is referred to as a "switch". All switches are interconnected, making the AUTOVON comparable to a commercial telephone exchange system. Although normally utilized for voice communications, future plans for AUTOVON include the capability of switching every type of information transfer, including teletype and data.

TERM DEFINITIONS

The following is a discussion of commonly used terms and their definitions that are helpful toward becoming conversant in AUTOVON operation:

1. AUTOVON Subscriber—An individual or installation having direct access to an AUTOVON switch.

2. AUTOVON User—An individual or installation having indirect access into the AUTOVON network by dialing a designated access code or by placing a call through a local private branch exchange (PBX).

320

3. AUTOVON Access Line — A circuit connecting an AUTOVON subscriber phone directly into an AUTOVON switch.

4. Conference Call — A call with two or more access lines connected.

5. Console — A control device connected to an AUTOVON switch controlling other access lines and phones in a local area. An example of this would be a console unit in a local command post, switching calls to and from several desk phones.

6. Diverse Routing — More than one access line serving the same installation but routed over geographically separate circuits.

7. Dual Homing — Connecting an AUTOVON terminal to be served by either of two switching centers, utilizing a single AUTOVON directory phone number.

8. Dual-Use Access Line — An access line that is normally designated for voice communications use but is specially configured for digital transmission, if needed.

9. Maximum Calling Area — Geographical calling limits imposed on a certain AUTOVON line.

10. Off-Hook Service — Automatic connection between subscribers when a handset is lifted. This service is normally limited to command and control or operational functions requiring rapid connection.

11. Off-Net Calling — Official long distance AUTOVON calls being interfaced to or from local commercial phones.

12. Preemption — The act of one subscriber completing an AUTOVON call by seizing telecommunications before or in preference to other subscribers' calls. An example of this would be an IMMEDIATE precedence call preempting a ROUTINE call that is already in progress.

13. Pre-Set Conference — A feature available to a group of AUTOVON users all wishing to confer together. This is accomplished by all the conference users dialing a prescribed AUTOVON number.

14. Random Conference — A conference call established among AUTOVON users on a case-by-case basis by requesting connection through an AUTOVON assistance operator.

CLASSES OF TELEPHONE SERVICE

Discussed below are the four classes of telephone service available on board military installations:

1. Class A (Official) — This service is available for transaction of official Government business on Department of Defense (DOD) or military installations and requires access to commercial telephone company trunks in order to properly conduct official business.

2. Class B (Unofficial) — This service is installed on or near a military PBX or CENTREX system and is authorized for personal or unofficial business. This telephone service must have access to commercial telephone company trunks.

3. Class C (Official Restricted) — This service is essentially the same as Class A service, except that it does not have access to commercial telephone company trunks.

4. Class D (Official-Special) — This is a telephone service installed on military installations for official business of the Government and is restricted to special classes of use, such as fire alarm, crash alarm, or security.

NOTE: Class A users may initiate outgoing phone calls for conducting official business in the AUTOVON network. Class B, C, and D telephones may not be used to initiate AUTOVON calls. Incoming calls may be connected to Class A and C telephones or extended, depending on the configuration and needs of the parent activity.

PRECEDENCE OF CALLS

All authorized users of voice communications facilities within the Department of Defense are directed to conform to standards of the Joint Uniform Telephone Communications Precedence System. The effectiveness of this system depends on the proper utilization of the precedence system by the user. Each user should be familiar with the system and the types of calls assigned each precedence. The user should exercise caution to ensure that his/her call is not assigned a precedence higher than the circumstance or information involved. The precedences and their applications listed below are for joint use and are listed in their relative order of priority in handling.

1. Flash—Reserved generally for calls pertaining to:

a. command and control of military forces essential to defense and retaliation.
b. critical intelligence concerning national survival.
c. conduct of diplomatic negotiations critical toward limiting or stopping hostilities.
d. civil alert information essential to national survival (large scale attack).
e. continuity of Federal Government functions essential to national survival.
f. critical internal security functions of the United States.
g. national or international catastrophes.

2. Immediate—Reserved generally for calls pertaining to:

a. situations which gravely affect the national security of the United States.
b. regrouping of forces in a post-attack period.
c. intelligence reports concerned with national security.
d. diplomatic negotiations toward reducing or limiting the threat of war.
e. implementation of Federal Government actions essential to national survival.
f. situations gravely affecting the internal security of the United States.
g. civil defense actions concerning the population and their survival.
h. serious disasters having an immediate effect on the welfare of the population.
i. vital information concerning aircraft, spacecraft, or missile operations.

3. Priority—Reserved generally for telephone calls requiring expeditious action by called parties and/or furnishing essential information for the conduct of Government operations.

4. Routine—Applies to those official Government communications which require rapid transmission but do not require preferential handling. These routine calls will be handled in an expeditious manner and in the order placed.

TYPES OF SERVICE

Within AUTOVON various types of service will provide for the needs of network users.

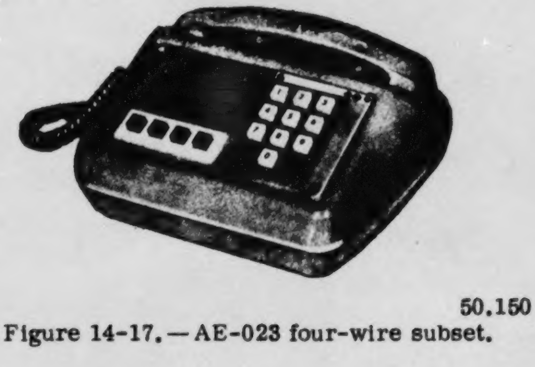
General Purpose Subscribers

Normal AUTOVON service provides a capability for subscribers to call other subscribers on a worldwide basis for day-to-day low precedence communications. Depending on the type of service provided in each locality, this service may be accomplished by either direct dialing or through a local operator.

Besides general purpose AUTOVON service provided through a local PBX, certain selected subscribers are authorized direct four-wire access to the general purpose network through pushbutton four-wire telephone sets (figure 14-17) installed in their offices. These subscribers may employ any level of precedence desired up to and including the highest level authorized for that unit.

Special Networks

Special networks may be provided within the AUTOVON. They may afford privacy of service within a specified community of interest by denying all such network subscribers access to any of the general purpose subscribers of the AUTOVON; or, selected subscribers of the special network may be granted access to the general purpose network. The trunks used to interconnect special network subscribers to each other usually are general purpose trunks and so are subject



50.150

Figure 14-17.—AE-023 four-wire subset.

to the normal operation of the multilevel precedence preemption system.

Off-Hook Service

Certain command, control, and other operational requirements are met by provision of automatic off-hook service. The equipment is so arranged that, when the telephone instrument is lifted off its cradle (off-hook), the circuit is immediately connected to a predesignated telephone instrument at the distant installation. These instruments cannot be utilized for any other purpose, and only the preset instrument(s) will be activated. This service is limited to command and control and operational functions requiring rapid connection.

Special Grade Service

Certain users, such as data and facsimile stations, will have access to specially conditioned trunks which provide the required transmission capability. These users are collectively called special grade users/subscribers, and the trunks and other facilities are similarly described as special grade trunks and/or facilities.

GENERAL USER INFORMATION

There is some essential information concerning AUTOVON that every operator or user should become familiar with prior to completing a call via AUTOVON. Local command policy will normally be to assure that AUTOVON is used only for the most essential official calls. Personal or unofficial calls must not be initiated into the AUTOVON network at any time.

Security

Telephone circuits, particularly those routed via high frequency (HF) and microwave, are susceptible to monitoring and interception. The AUTOVON is not secure, and operators and users are reminded that care must be exercised in accordance with established security instructions to avoid divulging classified information. "Giving hints" or "talking around" a classified subject usually leads to trouble.

AUTOVON Directory

An AUTOVON directory is published periodically and distributed to all subscribers connected to respective AUTOVON switches. This directory includes general instructions for placing calls over the AUTOVON system. It is not designed, however, for widespread dissemination at the user's installation. Applicable portions of the directory may be locally reproduced for internal distribution. Normally, all voice subscriber numbers which are commonly called by users should be published as a part of the local telephone directory. A complete list of AUTOVON voice numbers should be kept available at each Private Branch Exchange (PBX) operating position.

AUTOVON Assistance Operators

AUTOVON assistance by an operator is available as outlined in the current edition of the AUTOVON directory to assist the subscriber in completing calls and also to arrange conference calls when desired. The primary function of the assistance operator is to assist the subscriber in the completion of calls, but it is intended that the assistance of the operator be sought only after the subscriber has attempted a normal call via the appropriate automatic channels of the network. Instructions for requesting various types of assistance from the local AUTOVON assistance operator are included in the current AUTOVON directory. An AUTOVON assistance operator may provide such services as (1) directory service in providing AUTOVON numbers, (2) completing a call that a subscriber cannot reach directly, (3) establishing conference calls, or (4) receiving trouble reports if the trouble desk cannot be reached.

Trouble Reporting

Troubles may occur in the AUTOVON network which may cause interruption in an existing call or prevent a subscriber from initiating a new call. These troubles could exist in the subscriber's phone, on the access line to the switching center, in the switching center equipment, or in the trunks between switching centers. Troubles should be promptly reported in accordance with the instructions provided in the current issue of the AUTOVON directory.

AUTOSEVOCOM

The abbreviation AUTOSEVOCOM means Automatic Secure Voice Communications. This system is not available at all commands. Some of the commands within the AUTOSEVOCOM system use secure SEVOCOM switchboards and special circuits that link these commands together. Communication between commands linked by these circuits is established and conducted entirely in the secure mode. In other areas, AUTOVON phone circuits are utilized as the audio path, with the initial call-up being made in the unsecure mode. After contact has been established, the subscribers switch to the classified, or secure, mode of operation to conduct their business.

DEFINITIONS

Several terms are utilized in the AUTOSEVOCOM network. Some of the commonly used terms and their definitions are listed below:

1. Approved Circuit—A circuit which has been authorized by responsible authority for the transmission in plain language of information of a specific security classification.
2. Authentication—A security measure designed to protect a communications or command system against fraudulent transmissions.
3. Authorized User—An individual, activity, or organization which has been authorized the use of a subscriber terminal facility by competent authority.
4. Automatic Subscriber—A secure voice network terminal with the capability of dialing and completing a secure voice call without operator assistance.
5. Cross Talk—Sound heard in a receiver resulting from telephone currents in another channel.
6. "Go Cipher"—The term used to initiate necessary action to convert the equipment from plain language to the encrypted mode.
7. "Go Plain"—The term used to initiate necessary action to change equipment from the encrypted mode to the plain language mode.
8. Manual Subscriber—A secure voice terminal requiring operator assistance to place calls.
9. Narrowband Subscriber—A terminal whose ciphony equipment requires a transmission bandwidth of approximately 4 kHz.
10. Wideband Subscriber—A terminal whose ciphony equipment requires a transmission medium bandwidth of approximately 50 kHz.
11. Nonsecure Mode—Unencrypted mode of transmission during which classified information may not be discussed.
12. Military Precedence Designator—A word designating the precedence level of a call as defined in the Joint Uniform Telephone Communications Precedence System.

13. Preemption—The act of seizing communications facilities before or in preference to others.

14. Secure Conversion Area—The area where a wideband to narrowband interface is accomplished or a cryptographic key change is made.

15. Subscriber—The organization provided with a direct communication connection between its terminal facilities and a circuit switching center.

16. TSEC/KG-13—A transistorized, full duplex, digital key generator which, with appropriate ancillary equipment, provides encryption and decryption of multichannel teletypewriter, data, voice, and facsimile.

17. TSEC/KY-3—A transistorized, full duplex, wideband single channel speech security equipment.

GENERAL OPERATING PROCEDURES

In order to maintain effective operational service throughout the AUTOSEVOCOM network, it is necessary for all users to observe proper operating procedures while utilizing the services available. The operating instructions found in the local AUTOSEVOCOM subscriber's directory contain specific information concerning correct placement of calls.

Precedence

Precedences used via the AUTOSEVOCOM network are governed by the Joint Uniform Telephone Communications Precedence System (figure 14-18). The effectiveness of this system depends on the personnel utilizing it, and each user should exercise caution when considering whether a call requires a special precedence. It is improper procedure to request or utilize a precedence higher than the circumstance requires. Calls of a given precedence will not normally preempt calls of an equal precedence. For example, a priority call will not preempt a priority call already in progress.

Precedence designators are for joint use and specify the relative order in which telephone calls should be handled based on the importance (content) of the call.

Numerical Category: 1

Designator: **FLASH**

Application: Flash precedence is reserved for alerts, warnings, or other emergency actions having immediate bearing on National, command, or area security. Examples: Presidential use; announcement of an alert; opening of hostilities; land, air, or sea catastrophies; intelligence reports on matters leading to enemy attack; potential or actual nuclear accident or incident; implementation of services unilateral emergency actions procedures, etc.

Numerical Category: 2

Designator: **IMMEDIATE**

Application: Immediate precedence is reserved for vital communication (1) having an immediate operational effect on tactical operations; (2) which directly concern safety or rescue operations; or (3) which affect the intelligence community operational role. Examples: Initial vital reports of damage due to enemy action; land, sea, or air reports which must be completed from vehicles in motion such as operational mission aircraft; intelligence reports on vital actions in progress; natural disaster or widespread damage; emergency weather reports having an immediate bearing on mission in progress; emergency use for circuit restoration, use by tactical command posts for passing immediate operational traffic, etc.

Numerical Category: 3

Designator: **PRIORITY**

Application: Priority precedence is reserved for calls which require prompt completion for National defense and security, the successful conduct of war, or to safeguard life or property, which do not require higher precedence. Examples: Reports of priority land, sea, or air movement; administrative, intelligence, operational, or logistic activity calls requiring priority action; calls that would have a serious impact on military, administrative, intelligence, operational, or logistic activities if handled as a ROUTINE call. Normally, PRIORITY will be the highest precedence which may be assigned to administrative matters for which speed of handling is of paramount importance.

Numerical Category: 4

Designator: **ROUTINE**

Application: Routine precedence is reserved for all other official communications.

Notes:

1. Calls of any precedence may be preempted by the application of the FLASH OVERRIDE capability available to: (1) the President of the U.S., the Secretary of Defense, and the Joint Chiefs of Staff; (2) Commanders of Unified and Specified Commands when declaring either Defense Condition One or Defense Emergency; and (3) CINCNORAD when declaring either Defense Condition One or Air Defense Emergency.
2. Precedence designators FLASH through PRIORITY will be given preemption rights in the order of listing.

50.169

Figure 14-18.—Joint Uniform Telephone Communications Precedence System.

SECURITY REQUIREMENTS

Physical security at the secure conversion area of a switching center will be in accordance with requirements contained in KAG 1/TSEC series. Unrestricted use of the AUTOSEVOCOM system will be limited to those U.S. citizens possessing at least a Secret security clearance or higher.

Authentication

When information up to and including Secret is discussed, the AUTOSEVOCOM system is designed to be self-authenticating (no authenticating is required by conversing parties). All Top Secret conversations must be authenticated by the call originator, ensuring that the called party is cleared for receipt of the information to be discussed. Positive voice recognition may be used as an alternative authentication. This voice recognition is a dual responsibility of both the called and the calling party.

Violation Reporting

Physical security violations should be reported as prescribed in KAG 1/TSEC and CMS 4. Any user becoming aware of an inadvertent third party connection or hearing cross talk should report the occurrence to the switch operator serving the termination. The user should give the operator all known details to assist in correcting the deficiency. This report is in addition to any report required due to inadvertent disclosure of classified information.

OTHER SYSTEMS

The Navy has developed more automated systems dedicated to enhancing fast writer-to-reader time in message handling. With a more effective speed-of-delivery of message traffic, the volume of messages that can be handled is steadily increasing, producing efficiency beyond the dreams of the early communications pioneers. Some of the systems enhancing this speed of service are discussed below.

MESSAGE PROCESSING AND DISTRIBUTION SYSTEM (MPDS)

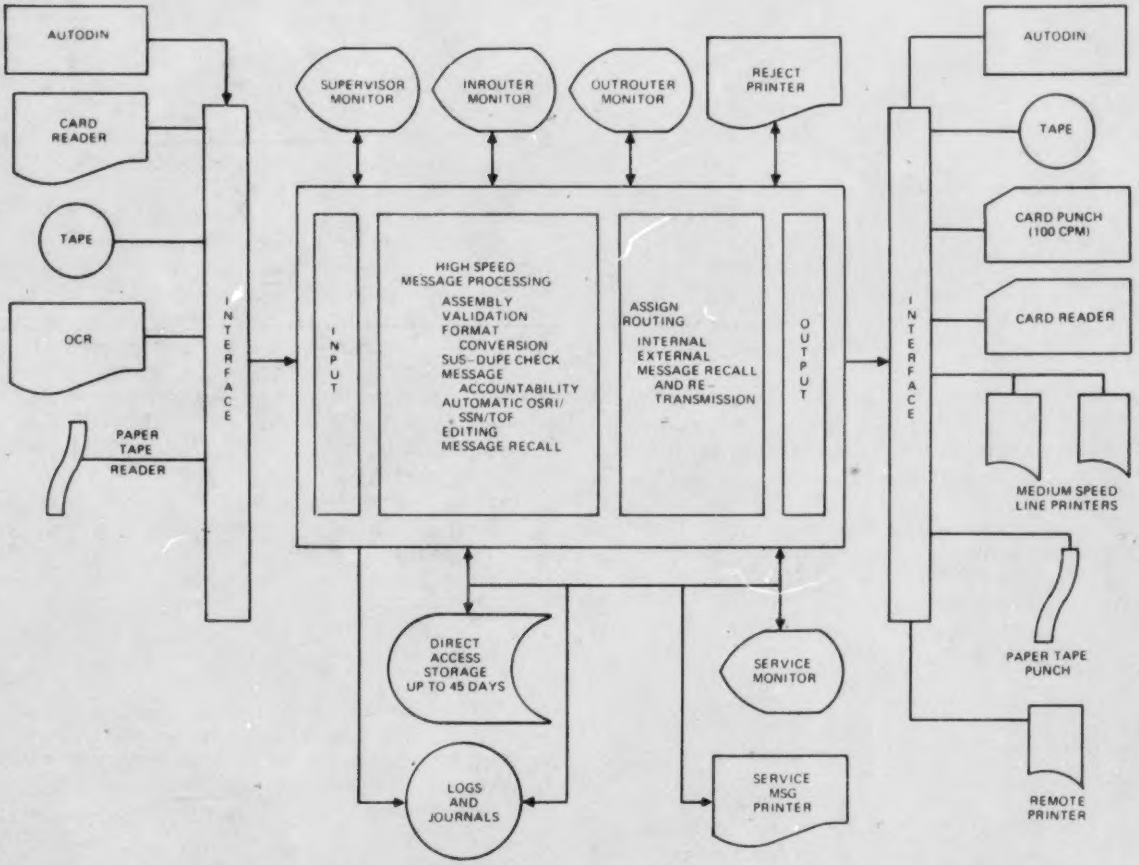
The Message Processing and Distribution System (MPDS) is a shipboard message switching system which processes, stores, logs, and internally routes record and digital data traffic to and from receive and transmit channels. This system can include twenty intra-ship terminals located in principal shipboard offices and operating spaces. When outgoing traffic is originated at each terminal, it is completely formatted, cleared for release, logged, and transmitted without manual intervention. The system includes a facility control console with a keyboard and display panel for semi-automatic circuit/equipment accounting and frequency management. This also aids in controlling remote HF equipment, telephone sets, a teletype for circuit coordination, and remote switching for secure voice circuits. The first MPDS system is installed on board *USS NIMITZ* (CVAN 68) and is designed to process in excess of 2500 messages per day.

LOCAL DIGITAL MESSAGE EXCHANGE (LDMX)

The Navy has developed, tested, and installed LDMX message handling systems at several locations to meet the current growth in data exchange requirements. The LDMX is a computerized communications system which automates the message processing functions of a communications facility to provide reliable, accurate communications and data exchange at high speed. The LDMX simultaneously transmits and receives messages over the DCA Automatic Digital Network (AUTODIN) and other remote terminal circuits to provide high speed processing, system reliability, secure communications, cost savings, and flexibility. The LDMX system concept is outlined in figure 14-19 and discussed below.

High Speed Processing

On-line to AUTODIN and other circuits, the LDMX system automatically receives, identifies, and files traffic for processing and future reference. Incoming messages are automatically arranged by precedence, processed, edited, and printed on reproducible mats for delivery. Outgoing traffic is entered via an optical character


AUTODIN
CARD READER
TAPE
OCR
PAPER TAPE READER
INTERFACE
SUPERVISOR MONITOR
INROUTER MONITOR
OUTROUTER MONITOR
REJECT PRINTER
INPUT
HIGH SPEED MESSAGE PROCESSING
ASSEMBLY
VALIDATION
FORMAT CONVERSION
SUS-DUPE CHECK
MESSAGE ACCOUNTABILITY
AUTOMATIC OSRI/SSN/TOF
EDITING
MESSAGE RECALL
ASSIGN ROUTING
INTERNAL
EXTERNAL
MESSAGE RECALL AND RE-TRANSMISSION
OUTPUT
INTERFACE
AUTODIN
TAPE
CARD PUNCH (100 CPM)
CARD READER
MEDIUM SPEED LINE PRINTERS
PAPER TAPE PUNCH
REMOTE PRINTER
DIRECT ACCESS STORAGE UP TO 45 DAYS
SERVICE MONITOR
LOGS AND JOURNALS
SERVICE MSG PRINTER

76.143

Figure 14-19.—LDMX system concept.

reader (OCR) or via magnetic tape, paper tape, or card reader. The system formats the outgoing message; creates a header; validates the message identifiers, precedence, and classification; searches system files to assign correct routing indicators; and arranges the message by precedence for automatic transmission. This LDMX system provides high speed communications processing to replace the slow, error prone manual operations. Operating at full capacity, the system can process up to 7500 messages per day.

System Reliability

Message processing reliability is greatly improved by automating message identification and header preparation and by providing system look-up files in lieu of manual files. By eliminating most manual functions and validating those remaining, the system greatly reduces misroutes and nondeliveries. The system works around the clock and provides virtually full time availability. Key devices can be switched from one application to another, and there is a full range of excess equipment that could be installed. The system can continue to operate in a semiautomatic or manual mode if a major component is inoperable.

Secure Communication

All message security fields are validated, and if a mismatch is detected in the LDMX system, the message is displayed to an inrouter or an outrouter for review and action. Depending on the user's requirements, video display terminal (VDT) operators may be prevented from displaying or recalling Top Secret and SPECAT messages, thus reducing the possibility of a security violation.

Cost Savings

By reducing the dependency on manual functions, the LDMX system provides reliable and secure high speed message processing capabilities that will handle anticipated increases in traffic without increases in manpower and equipment. One LDMX system can replace several manual communications centers and provide greater accuracy and higher processing speed than the manual systems combined.

Flexibility

The LDMX system eliminates most manual processing without imposing stringent limitations on the user. Tailored to meet the unique situations at each command, the LDMX can be responsive to individual command requirements and variances.

Statistical and Management Reports

A significant feature of the LDMX system is the natural accumulation of statistical information and accounting data which provides accurate verification of the reliability and performance of the system. Message processing data is summarized in a series of statistical analysis summaries that includes:

1. A bar chart providing an hourly volume of incoming or outgoing messages.

2. A summary report showing the number and average length of incoming or outgoing messages, the number of messages delivered to a remote printer, and the number of various classifications and precedences.

3. A listing of service messages sent and received.

4. A listing with information concerning duplicated, misrouted, and missent messages.

5. A speed of service report, giving maximum, average, and minimum processing times (by precedence, classification, or selected originator).

NAVAL COMMUNICATIONS PROCESSING AND ROUTING SYSTEM (NAVCOMPARS)

The Naval Communications Processing and Routing System (NAVCOMPARS) is an automated communications processing and routing system which provides the interface between circuits ashore and those serving the fleet. The NAVCOMPARS automatically performs the functions of maintaining a real-time fleet locator, servicing messages, formatting, screening, readdressal, and routing. Its primary purpose is to serve the fleet, although it is designed with LDMX modules to serve shore based users, if needed. NAVCOMPARS has made the job of a shipboard Radioman much easier by eliminating the requirement to place routing indicators on outgoing message traffic. There is no longer a requirement for ships utilizing NAVCOMPARS to maintain ACP 117 on board. The system allows afloat units to send messages via termination, ship/shore, or satellite in a "modified ACP 126" format, which requires the addition of JANAP 128 format lines 2, 4, 15, and 16 to the normal ACP 126 format. Other advantages of the NAVCOMPARS are automatic message processing, automatic routing indicator lookup and format conversion, security protection, suspected duplicate checks, automatic file and retrieval, automatic reaction to special operating signals, and visual display of garbles or errors for operator intervention.

Format Compatibility in NAVCOMPARS

In order to obtain the full benefits of NAVCOMPARS, the message originator and communications personnel must prepare messages in the prescribed format. If there is an error in format construction, it can cause a message to be rejected by the NAVCOMPARS, or it may cause the NAVCOMPARS to reject one of the addressees. The format requirements outlined in NTP 4 for NAVCOMPARS must be followed to effect proper delivery of message traffic.

Plain Language Address Directory (PLAD)

The only authorized source of short titles and geographical locations in message addressees is the Plain Language Address Directory (PLAD). The PLAD is disseminated and controlled by COMNAVTELCOM as a supplement to NTP 3. The PLAD provides authorized listings of approved addresses and is intended for the use of message drafters. Copies of NTP 3 (with the PLAD Supplement) should be disseminated to all users who draft messages within the command. The PLAD normally contains plain language addresses for Navy, Marine Corps, and Coast Guard commands and is updated frequently by "ALCOM" general message corrections.

Message Paging Via NAVCOMPARS

The NAVCOMPARS system is configured to accept messages with up to 37,000 continuous characters. With this system, a fleet unit operating directly with a NAVCOMMSTA equipped with NAVCOMPARS may transmit up to 550 continuous lines of message headings and text without dividing the message into two sections. A fleet unit terminated with a NAVCOMMSTA not equipped with NAVCOMPARS may transmit up to 100 lines of continuous text, exclusive of heading lines.

SATELLITE INFORMATION EXCHANGE SYSTEMS (IXS)

The purpose of Satellite Information Exchange Systems (IXS) is to link subscribers together, enabling them to exchange information via a specific satellite path. Included in the IXS are the Submarine Satellite Information Exchange Subsystem (SSIXS) and the Common User Digital Information Exchange Subsystem (CUDIXS).

Submarine Satellite Information Exchange Subsystem (SSIXS)

The SSIXS has been designed and is being installed in SSN/SSBN submarines to complement the existing communications capabilities on board submarines. It is designed as an extra communications function and does not replace any existing facilities. The SSIXS has two modes of operation. One is the broadcast mode, enabling the shore terminal to send selected portions of the submarine broadcast files. The other mode is the query/response (or calling and answering) operation, where the underway unit has the option to transmit and receive traffic from the shore terminal. Submarine subscribers will normally utilize the modified ACP 126 format procedures via this system. Each SSIXS network can support a community of up to 60 subscribers.

Common User Digital Information Exchange Subsystem (CUDIXS)

CUDIXS is the link control or automated information subsystem developed to enable rapid exchange of information between fleet mobile subscribers and activities ashore. Ships will be assigned to the CUDIXS network by the Fleet Commander in Chief (FLTCINC) and normally will only be active members during operations at sea. Active network participation during in-port periods will be authorized only where there are no local message distribution services or when specifically directed by the FLTCINC. CUDIXS is designed to process message traffic in modified ACP 126 format. Since the shore terminal will automatically convert the traffic to JANAP 128 format, caution should be exercised by the shipboard operators to follow rigidly correct format procedures and to utilize correct Plain Language Addresses from the PLAD supplement to NTP 3.

CHAPTER 15

FLEET COMMUNICATIONS

A commanding officer must be able to communicate whenever necessary with both ships and shore stations to maintain effective command and control of the situation at hand. Communications is still and always will be the "Voice of Command." In this age of nuclear weapons, guided missiles, supersonic aircraft, and high speed submarines, top performance is required of our fleet communicators. Therefore, they must always remain in a condition of constant preparedness.

The Navy has phased out many of its older ships during the last decade and has commissioned many new ones. Along with the modern ships, many up-dated computerized communications systems have been implemented.

The information in this chapter may seem of most use to the "sea-going" Radioman, but all personnel in the communications community should be familiar with the information for preparation for sea duty.

FLEET MULTICHANNEL BROADCAST SYSTEM ("N" SYSTEM)

The Fleet Multichannel Broadcast (MULCAST) System is now the primary means of delivering message traffic to ships. It has replaced the single channel radioteletype system. The MULCAST is keyed by the automated Naval Communications Processing and Routing System (NAVCOMPARS) and is transmitted via satellite, low (LF), medium (MF), and high (HF) frequencies. The HF component of the MULCAST is transmitted via several frequencies at the same time to enable the ships to pick the best reception for their location. Through the use of multiplex equipment, the MULCAST provides the opportunity for the delivery of large quantities of traffic with a small number of transmitting stations. The MULCAST provides a linking network to support communications coverage to all ocean areas of the world.

The ocean areas mentioned are divided into four Naval Communications Areas (NAVCOMMAREA), as shown in figure 15-1. Each NAVCOMMAREA has a Naval Communication Area Master Station (NAVCAMS) tasked with the responsibility of coordinating fleet broadcasts as well as other communications circuits within their areas. There are NAVCAMS at Norfolk, Naples, Honolulu, and Guam. acting as NAVCAMSLANT, NAVCAMSMED, NAVCAMSEASTPAC, and NAVCAMSWESTPAC, respectively.

BROADCAST CONTROL

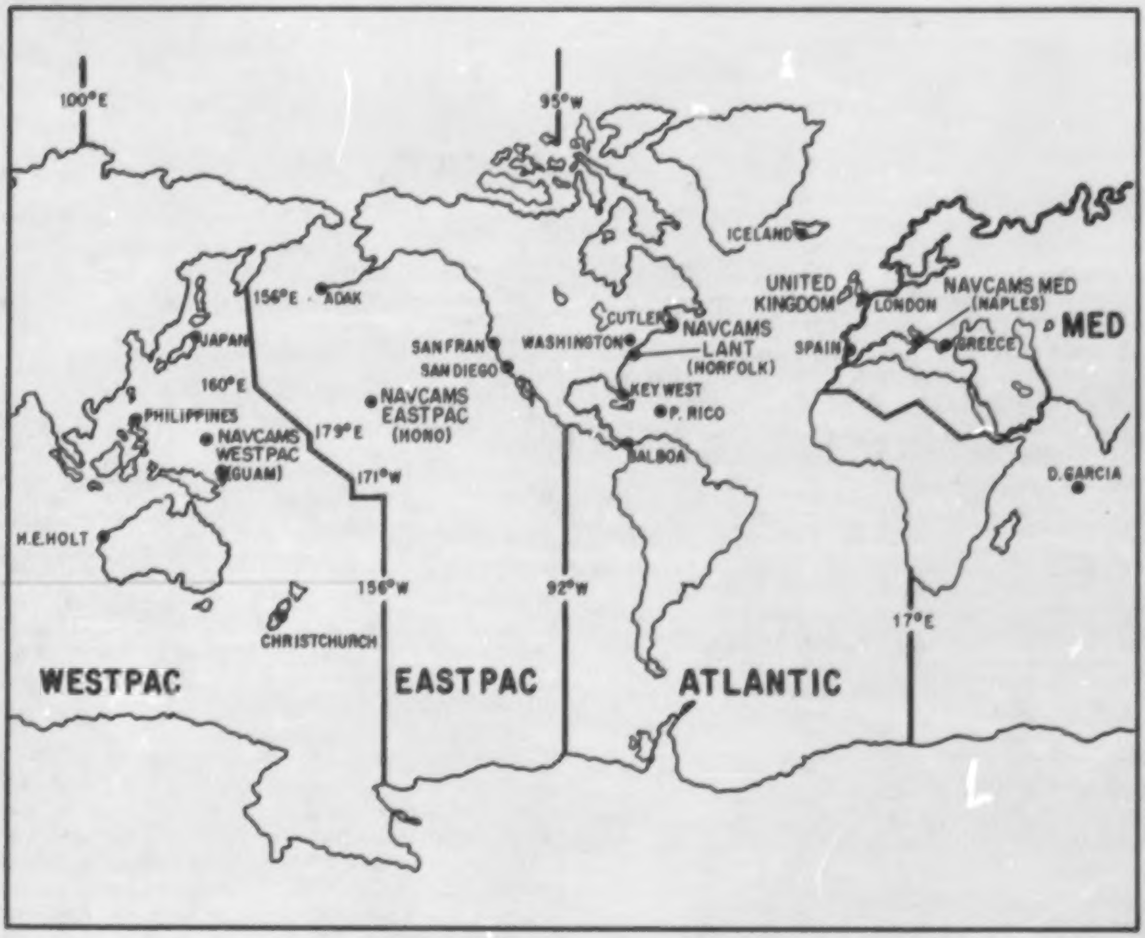
The Broadcast Control Authority (BCA) is the controller of a specific broadcast. Normally, the authority is under the cognizance of the Fleet Commander in Chief or a Force Commander. The BCA directs the implementation of the broadcast and provides direction and guidance toward its configuration and content. The BCA may control the broadcast completely, or it may assign some responsibility to a subordinate command.

The Broadcast Control Station (BCS) is the activity that engineers the broadcast and delivers the keying to the transmitting stations. The NAVCAMS usually assembles the keystreams for all channels of a broadcast and delivers keying to the transmitter station.

The Broadcast Keying Station (BKS) is the activity responsible for placing the message traffic directly into the broadcast. Different stations may operate as BKSs on the same broadcast, but on separate channels.

A Broadcast Radiating Station (BRS) is a station responsible for radiating a signal from a broadcast supplied by the BCS and may or may not be a NAVCOMMSTA.

330


100°E
95°W
ICELAND
UNITED KINGDOM
LONDON
NAVCAMS MED
(NAPLES)
MED
SPAIN
GREECE
156°E
ADAK
CUTLER
NAVCAMS
LANT
(NORFOLK)
JAPAN
SAN FRAN
WASHINGTON
SAN DIEGO
160°E
KEY WEST
NAVCAMS
EASTPAC
(HONO)
P. RICO
PHILIPPINES
NAVCAMS
WESTPAC
(GUAM)
179°E
BALBOA
171°W
D. GARCIA
H.E.HOLT
156°W
92°W
17°E
CHRISTCHURCH
WESTPAC
EASTPAC
ATLANTIC

76.144

Figure 15-1. — Communications area master stations.

BROADCAST IDENTIFICATION

Multichannel broadcasts are assigned designators for identification. The first letter of the designator identifies the naval communication area, and additional letters let us know the type of broadcast it is. For example, a broadcast beginning with a "K" originates from the Mediterranean Communication Area (Naples), and an "N" means the broadcast is from the Atlantic (Norfolk) Communication Area. So, a broadcast with the designator NMUL is a multichannel broadcast (MUL) in the Atlantic COMMAREA, and one with a designator KSUB is a submarine broadcast (SUB) in the Mediterranean COMMAREA. A complete list and description of broadcast designators can be found in NTP 4.

A typical multichannel broadcast (N) system consists of receiving antennas, the antenna multicoupler, two receivers (if diversity reception is employed), AN/UCC-1 multiplex equipment, the TSEC/KWR-37 and TSEC/KG-14 crypto equipments, and a teletype machine for each channel copied. The receivers are patched to the AN/UCC-1 via the receiver audio switchboard. The output of the AN/UCC-1 is patched via the black DC patch panel to the crypto equipments, and the output of the crypto equipments are patched to the teletype machines via the red DC patch panels. An illustration of how the equipment is connected through the patch panels and switchboards to develop the communication system is shown in figure 15-2.

Reception of the multichannel broadcast via satellite will be discussed later in this chapter.

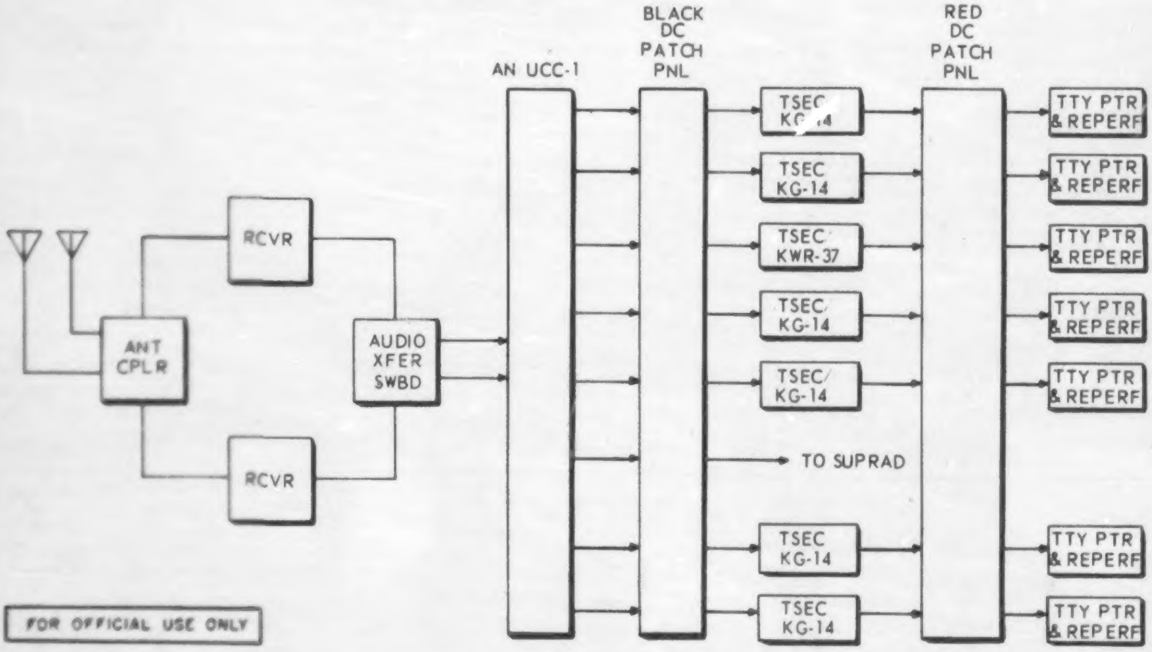
The multichannel broadcast is divided into sixteen channels. Ships copying the broadcast are matched to broadcast channels by class according to similarities of mission, task, and equipment capabilities. Each ship is assigned a primary channel to copy for traffic and a secondary channel to copy for reruns or overload traffic. The secondary channel transmits the same traffic as the primary channel one hour later. This enables a ship to pick up missing numbers on the broadcast within one hour by copying the secondary channel. Ships are not required to copy the secondary channel unless they miss a broadcast number or unless the channel is activated as an "overload" channel for "first run" traffic. If the secondary channel is activated for "first run" traffic, the notification message informing operators is sent giving sufficient notice via the primary channel. Broadcast channel alignment is outlined in NTP 4, Section 2.

BROADCAST OPERATION

The Fleet Multichannel Broadcast (MULCAST) is operated continuously and requires restart at the beginning of each new crypto day and also each time the synchronization is lost. The TSEC/KWR-37 crypto device is used for the decryption of message traffic on specific broadcast channels. It also provides timing for the TSEC/KG-14 on other channels.

A spare TSEC/KWR-37, if available, should be prepared for the new radio day by inserting the new day's key card in the holder approximately 45 minutes prior to daily restart time. The actual patching of the new TSEC/KWR-37 should not take place until about one minute prior to restart time so that reception of high precedence traffic is available up to the last minute.

Every Radioman on board should be thoroughly familiar with the operation of the TSEC/KWR-37. The operating instructions for this equipment


BLACK DC PATCH PNL
RED DC PATCH PNL
AN UCC-1
TSEC KG-14
TSEC KG-14
TSEC KWR-37
TSEC KG-14
TSEC/ KG-14
TO SUPRAD
TSEC KG-14
TSEC KG-14
TTY PTR & REPERF
TTY PTR & REPERF
TTY PTR & REPERF
TTY PTR & REPERF
TTY PTR & REPERF
TTY PTR & REPERF
TTY PTR & REPERF
RCVR
RCVR
ANT CPLR
AUDIO XFER SWBD
FOR OFFICIAL USE ONLY

50.198

Figure 15-2.—Fleet Multichannel Broadcast ("N" System).

]

are contained in the publication KAO-34 (series) and will provide all operating personnel with helpful hints to keep your broadcast file up to date with the least amount of "missing numbers".

BROADCAST SHIFTS

There will be times occasionally when a ship has the requirement to shift from one broadcast to another. If a ship transits the Atlantic, for instance, it is not feasible that the Radioman will be able to copy the Norfolk (Atlantic) broadcast during the entire trip without reception problems. Normally, there should be a broadcast shift to the Mediterranean (Naples) broadcast at about the half-way point during the transit.

The shift from one broadcast to another or a shift off the broadcast should be accomplished at 0001Z. The broadcast shift message should be sent early enough so that it reaches the common source file authorities at NAVCAMSLANT Norfolk, VA and NAVCAMSEASTPAC Honolulu, HI by 1600Z on the day before the radio day of the shift. In the case of an emergency broadcast shift, the ship should commence copying the new broadcast immediately. It should continue to copy the original broadcast for as long as possible, or until the originally scheduled time of the shift occurs. The notification of an emergency shift message should be sent with a PRIORITY or IMMEDIATE precedence. A format example for broadcast shift messages can be found in NTP 4, and updated information may be promulgated by the NAVCAMS Communication Information Bulletins (CIBs).

BROADCAST FILE

The broadcast file contains a copy or filler for each message transmitted or received on the broadcast. The file is stored in accordance with the highest classification of the information contained in the file. Segregated stowage by classification is not required. Broadcast copies, carbons, and tapes are safeguarded in accordance with OPNAVINST 5510.1 (series) and must be retained for a period of ten days. Top Secret messages received but not addressed to an afloat command should be removed from the broadcast copies, and ticklers should be entered in the broadcast file in lieu of the Top Secret message. The Top Secret message should be destroyed immediately by authorized methods. The destruction should be certified by two witnessing officials who place their initials next to the appropriate broadcast serial number on the check-off sheet. These check-off sheets are exempted from the regulation requiring that certificates of destruction be retained for two years but, instead, are destroyed with the broadcast files after ten days. Top Secret traffic handled by NAVCOMMSTAs for relay or broadcast delivery need not be controlled as described in OPNAVINST 5510.1 (series) and DODINST 5200.1, providing all copies (except the monitor roll and monitor reel) are destroyed immediately after they have served their purpose. Monitor copies must be marked Top Secret and afforded appropriate security and storage. These monitor copies may be destroyed after the mandatory retention period, with proper documentation.

Missed Broadcast Messages

If a ship misses broadcast messages, the Radiomen should make all attempts to obtain the missing messages from ships in company or other fleet units via local circuits, visual means, or messenger. If the messages are not available locally, then the ship must ask for a retransmission of the messages from the broadcast station. The retransmission request sent by the ship is called a Broadcast Screen Request. The screen request is sent "action" to the BKS and "information" to the appropriate NAVCAMS. Any unit requesting a retransmission of more than 25 missing broadcast numbers must include their numbered Fleet Commander (e.g., COMSEVENTHFLT, COMSECONDFLT) as an information addressee.

A complete copy of missed messages not addressed to the ship's guardlist need not be obtained. Heading fillers of heading recaps can be substituted in place of the complete message. Once an hour, a message summary heading recap is sent on each first-run broadcast channel. This recap supplies the headings of the previous hour's traffic. This is an excellent means of recovering messages that may have been missed during the previous hour via the broadcast.

Broadcast Check-Off Sheets

The form utilized as the broadcast circuit log and destruction sheet (check-off list) lists the number of messages received/transmitted via the broadcast and the classification of each message. The form also serves as the record of destruction for the classified messages in the file. An example of this form is shown in figure 15-3. The form is not available through the Navy Supply System, but it may be reproduced locally for use.

OTHER BROADCASTS

As previously stated, the most popular means of message traffic delivery to the fleet is via the multichannel broadcast. There are ships in the Navy, however, that do not have the capability or the need to copy a multichannel broadcast. The ship may not have the multiplex equipment installed, or the assignments or mission of the ship may require it to copy one or more of the following broadcasts.

SINGLE CHANNEL BROADCAST

If a ship is not equipped to copy the multichannel broadcast, then it must be a subscriber to a single channel broadcast. The single channel broadcasts are identified by "RTT" or "SPG" preceded by the COMMAREA designator letter. For example, the LANTSOAM (Norfolk) single channel broadcast has the designator NRTT.

The single channel broadcasts are keyed continuously and require cryptographic restarts at the beginning of each new crypto day or whenever synchronization is lost. Frequencies in the LF/MF/HF ranges are assigned to the broadcasts by the area CAMS in Communications Information Bulletins (CIBs). The cryptographic equipments used on a single channel broadcast can be either the TSEC/KW-37 or the TSEC/KW-7CR. A frequency shift converter (usually an AN/URA-8 or AN/URA-17) is used on the single channel broadcast in lieu of the AN/UCC-1 that is required for the multichannel broadcasts.

The guidelines concerning service messages, missing number procedures, stowage and retention of files, and message format are the same as outlined previously for the multichannel broadcasts.

Submarine Broadcasts

Several frequency shift keying (FSK) single channel submarine broadcasts have been established to provide a means of communications from force commanders to their operational units. These broadcasts are the primary means of telecommunications to submarines underway. Broadcast operations and traffic content are carefully controlled by the BCA to accommodate various submarine operations. Cryptographic start times are staggered to avoid more than one broadcast from being off the air at the same time for cryptographic restarts. Each schedule begins on a prescribed hour. The first message is a traffic list (ZBO) to let each submarine determine the need for further copy. Messages are repeated three, four, six, or twelve times, depending on the operational requirements.

A new multichannel submarine broadcast system called VERDIN using minimum shift keying (MSK) has been developed to replace the existing single channel FSK broadcast. Some VERDIN shore terminals have already been constructed, and more will be completed in the near future. VERDIN installations on U.S. submarines should be completed during 1979.

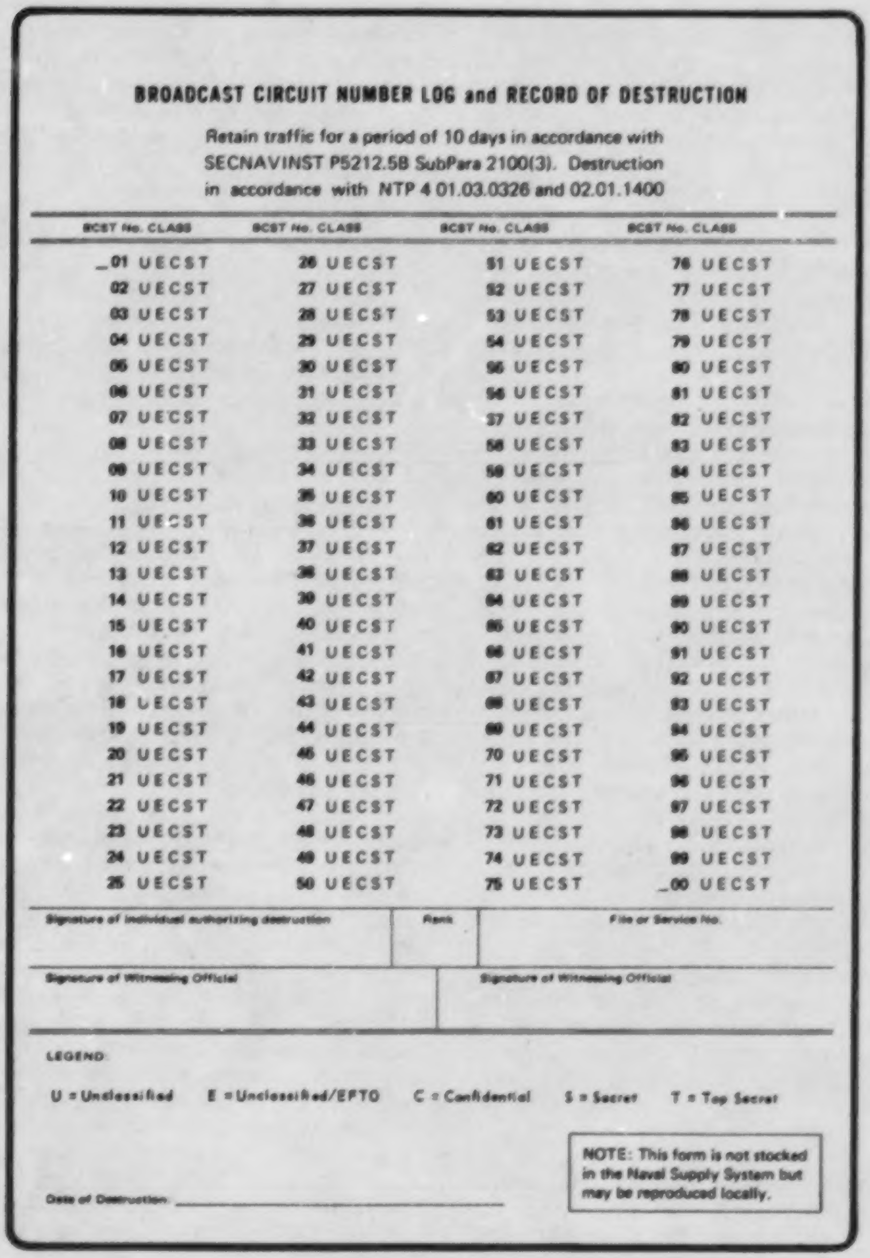
Composite Fleet/ General Broadcast

The Composite Fleet/General Broadcast (CMP) is a CW broadcast used by those fleet units unable to copy a covered broadcast (either the MUL or RTT). The broadcast is keyed on a scheduled basis for U. S. Fleet units, providing narrative message traffic, weather, and hydrographic messages. This broadcast also serves Allied ships and other authorized users on a preset schedule. The fleet schedule is maintained only for the use of U. S. and friendly foreign warships.

Transmissions of fleet schedules consist of a call-up transmitted five minutes prior to commencement of the schedule. This call-up will consist of the called station call sign sent three times, the prosign "DE" followed by the call sign of the calling station sent three times, and the word "FLEET." An example is as follows: NERK NERK NERK DE NAB NAB NAB FLEET.

When it is time for the schedule to commence, the same procedures as set forth above are used, except this call will be preceded by a series of eight "Es" and will include the appropriate operating signal for the number of messages to be transmitted (ZBO). An example is as follows: EEEEEEEE NERK NERK NERK DE NAB NAB NAB ZBO 04. After this is sent, the transmitting station can commence sending traffic.

If a message is received for relay at the transmission station after the schedule has



BROADCAST CIRCUIT NUMBER LOG and RECORD OF DESTRUCTION

Retain traffic for a period of 10 days in accordance with SECNAVINST P5212.5B SubPara 2100(3). Destruction in accordance with NTP 4 01.03.0326 and 02.01.1400

BCST No.	CLASS	BCST No.	CLASS	BCST No.	CLASS	BCST No.	CLASS
_01	U E C S T	26	U E C S T	51	U E C S T	76	U E C S T
02	U E C S T	27	U E C S T	52	U E C S T	77	U E C S T
03	U E C S T	28	U E C S T	53	U E C S T	78	U E C S T
04	U E C S T	29	U E C S T	54	U E C S T	79	U E C S T
05	U E C S T	30	U E C S T	55	U E C S T	80	U E C S T
06	U E C S T	31	U E C S T	56	U E C S T	81	U E C S T
07	U E C S T	32	U E C S T	57	U E C S T	82	U E C S T
08	U E C S T	33	U E C S T	58	U E C S T	83	U E C S T
09	U E C S T	34	U E C S T	59	U E C S T	84	U E C S T
10	U E C S T	35	U E C S T	60	U E C S T	85	U E C S T
11	U E C S T	36	U E C S T	61	U E C S T	86	U E C S T
12	U E C S T	37	U E C S T	62	U E C S T	87	U E C S T
13	U E C S T	38	U E C S T	63	U E C S T	88	U E C S T
14	U E C S T	39	U E C S T	64	U E C S T	89	U E C S T
15	U E C S T	40	U E C S T	65	U E C S T	90	U E C S T
16	U E C S T	41	U E C S T	66	U E C S T	91	U E C S T
17	U E C S T	42	U E C S T	67	U E C S T	92	U E C S T
18	U E C S T	43	U E C S T	68	U E C S T	93	U E C S T
19	U E C S T	44	U E C S T	69	U E C S T	94	U E C S T
20	U E C S T	45	U E C S T	70	U E C S T	95	U E C S T
21	U E C S T	46	U E C S T	71	U E C S T	96	U E C S T
22	U E C S T	47	U E C S T	72	U E C S T	97	U E C S T
23	U E C S T	48	U E C S T	73	U E C S T	98	U E C S T
24	U E C S T	49	U E C S T	74	U E C S T	99	U E C S T
25	U E C S T	50	U E C S T	75	U E C S T	_00	U E C S T

Signature of individual authorizing destruction	Rank	File or Service No.

Signature of Witnessing Official	Signature of Witnessing Official

LEGEND:

U = Unclassified E = Unclassified/EFTO C = Confidential S = Secret T = Top Secret

Date of Destruction ______________________

NOTE: This form is not stocked in the Naval Supply System but may be reproduced locally.

76.145

Figure 15-3. — Broadcast circuit log and record of destruction.

commenced, the operator should put the message into proper format, assign it the next open broadcast number, and send it out on the schedule already in progress. If the new message is of a higher precedence than those on the schedule to be transmitted, the new message of higher precedence should be inserted out of sequential order into the schedule. The broadcast number of that message should be sent, preceded by the operating signal "ZIA."

After all fleet traffic has been transmitted, a "QRU" tape should be transmitted once. A fleet QRU tape consists of the call sign of the called station transmitted three times, the prosign "DE" followed by the call sign of the calling station sent three times, the last broadcast number sent, the operating signal "QRU," followed by the prosign "AR." An example follows: NERK NERK NERK DE NAB NAB NAB NR 004 QRU AR.

If, at the time of the next schedule the transmitting station has no new traffic for the broadcast, the operator should use the "QRU" tape from above, except the tape should be preceded by a series of eight "Es". As an example: EEEEEEEE NERK NERK NERK DE NAB NAB NAB NR 004 QRU AR.

The Merchant Ship Broadcast (MERCAST) is used to deliver U. S. Government originated message traffic to MSC ships and Navy controlled merchant ships in accordance with NTP 10. The schedules on the MERCAST are a portion of the Composite Fleet/General Broadcast and are keyed by a COMMSTA in each designated area for ships copying the MERCAST. Detailed information concerning MERCAST systems during peacetime is found in publication H. O. 117, where a listing of stations, schedules, frequencies, hydrographic data, ice reports, and time signals are available. ACP 149 contains the wartime schedules and frequencies of each Allied MERCAST area.

The MERCAST is primarily a CW broadcast with a normal operating speed of 25 words per minute. Speed may be increased up to a maximum of 29 words per minute after subscribers have been notified of the increasing transmission speed.

Another component of the Composite Fleet/General Broadcast is the Hydrographic Schedule. It consists of messages providing hydrographic information, Coast Guard Notices to Mariners (navigational aids), and Notices to Airmen (NOTAMS). Normally, they are addressed to "HYDROLANT" or "HYDROPAC," depending on the area affected. The call up is sent five minutes prior to the transmission of the hydrographic schedule to enable the receiving station to prepare to copy.

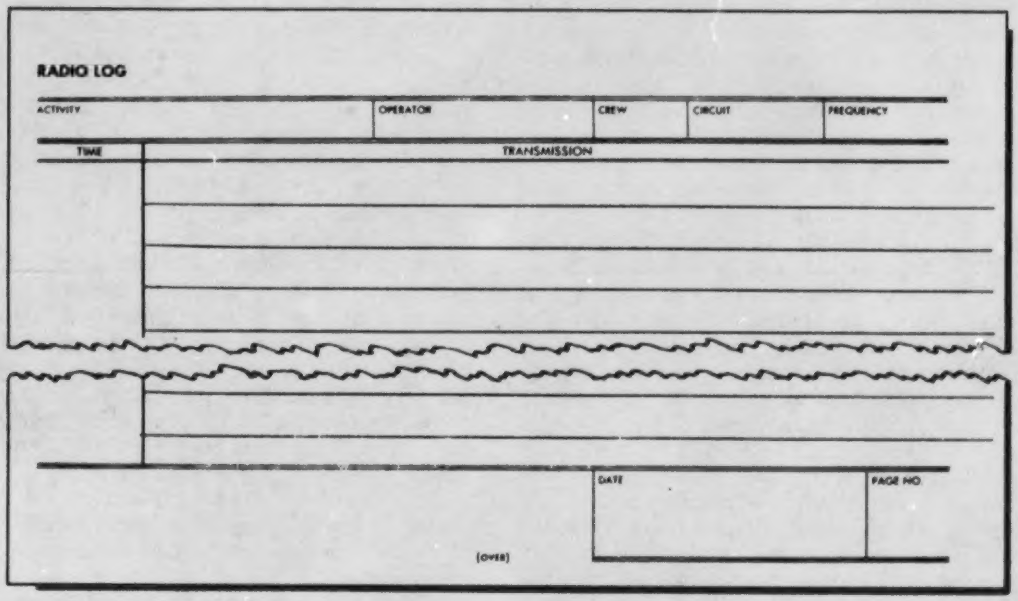
Weather Schedules are storm warnings, forecasts, fallout reports, etc. Forecast and weather warnings provide information such as air observations required for flight operations. The schedule and frequencies for these broadcasts are contained in the COMMAREA Communications Information Bulletins (CIBs). The publication H. O. 118 also provides frequencies and area coverage of non-Navy weather broadcasts. Ships and bases with a weather unit on board are required to copy at least the synoptic schedules of the Navy weather broadcast for their respective areas of operation. Ships and bases without weather units on board do not have a requirement to copy a weather broadcast, but this is at the discretion of the commanding officer or other competent authority.

All messages sent or received on the Composite Fleet/General Broadcast schedules must be filed in the communications center in date-time group order.

If any of the Composite Fleet/General Broadcast schedules are guarded, covered, or copied, the operators must maintain a radio log. This log is used to record each transmission heard on the circuit, whether it is addressed to his station or not. Commands may utilize OPNAV Form 2810-1 (Radio Log) or a locally reproduced form as shown in figure 15-4. If a message is addressed to or relayed by the receiving station, the message may be typed on a message form instead of in the log, and only the essential accounting information (time-of-receipt, originator, date-time group), need be entered in the log. The radio log should also record operating conditions of the circuit, opening and closing down of the net, causes for traffic delays, frequency changes, and any unusual circumstances noted by the operators. As the watch changes and the operator is relieved, he must sign the log in ink. This is also a requirement when a net or circuit is closed down. An entry must be made in each radio log at least every five minutes. If the operator on watch is too busy to comply every five minutes, he may enter the essential information later, indicating the times.

Facsimile Broadcast

The facsimile broadcast is normally used to receive weather maps transmitted by designated shore facilities. The system consists of the



RADIO LOG

ACTIVITY	OPERATOR	CREW	CIRCUIT	FREQUENCY

TIME	TRANSMISSION

DATE	PAGE NO.

(OVER)

76.146

Figure 15-4. — Radio log.

receiving antenna system, an HF receiver, a facsimile converter, and the facsimile recorder. Keying for the transmission of facsimile broadcasts is controlled by the local communications activity. Facsimile terminal equipment is provided to those naval meteorological offices that prepare weather maps for transmission on the broadcast and is not physically located near the controlling communications facility.

The material transmitted on a facsimile broadcast is assigned serial numbers running consecutively for each calendar month. For continuity, the transmitting station should provide a daily recapitulation containing a list of that day's transmissions, showing the time of each transmission and the associated serial number.

It is imperative that facsimile transmitting stations commence their schedules on time. Prior to commencing a schedule, each station normally should make a preliminary test call for approximately five minutes before the schedule is to begin. After the test call, the synchronous signal is transmitted at least two minutes before the schedule time to enable the receiving stations to synchronize their equipment for usable reception.

SHIP/SHORE AND SHIP/SHIP CIRCUITS

Earlier we discussed the principal of the fleet broadcast and how it is used to deliver the largest percentage of message traffic to operating ships. Now we will discuss the means by which an operating ship can transmit its message traffic ashore or to other ships for delivery or relay.

Until the early 1960s, the primary means of communications for a ship was via CW. CW transmissions were stable and had a great capacity for long-range transmission. However, the slowness of transmission, necessity for repetitions, the cumbersome security measures, and the increasing volume of message traffic greatly detracted from the usefulness of CW. This led to the radioteletype (RATT) circuits, which are the primary means of ship/shore communications today.

SHIP/SHORE NETWORK

Ship/shore circuits are established by designated NAVCOMMSTAs and NAVCOMMUs to accept and relay traffic from afloat commands.

There are enough of these ship/shore circuits in existence to allow a ship while at sea worldwide coverage for transmitting its traffic. The send and receive frequencies for each COMMSTA or COMMU are promulgated by the NAVCAMS of the particular NAVCOMMAREA by the Communications Information Bulletins (CIBs). The normal speed of operation on U. S. ship/shore circuits is 100 words per minute. For operations with NATO or other Allied stations, the operating speed may differ due to limitations of equipment. Normally, detailed operating procedures for Allied circuits can be found in fleet commander's operation orders or in ACP 176. Primary fleet ship/shore circuits are cryptographically protected (on-line) single channel radioteletype circuits permitting random access for a fleet unit to transmit traffic. These circuits improve the capacity, speed, and security of ship/shore communications. These cryptographically protected circuits are normally referred to as ORESTES circuits (covered by a TSEC/KW-7CR equipment).

ORESTES circuits can be operated in the duplex, semiduplex, or simplex mode of operation, depending mainly upon the amount of equipment available. In full duplex operation, each station transmits on a different frequency, and both can transmit at the same time. (A station sends on one frequency and receives on another.) Semiduplex is an operation which is duplex at one end of the circuit and simplex at the other. Semiduplex operation still requires two frequencies, except one of the stations cannot transmit and receive at the same time. An example of this situation could be a ship having only one TSEC/KW-7CR equipment available. The TSEC/KW-7CR would be used for both transmit and receive purposes on the ship/shore circuit so the operator could not transmit and receive traffic at the same time. Simplex is an operation providing one channel (one frequency) on which traffic can be exchanged. All stations on the net can both transmit and receive but not at the same time. The operator must wait to transmit until the receive function is completed. This simplex operation is normally reserved for UHF and for those ships that do not possess sufficient equipment for duplex or semiduplex operation.

Net Control Authority

The NAVCOMMSTA is the net control station on all ship/shore circuits unless the senior station or higher authority directs otherwise. The net control station will ensure the assignment of fully qualified operators to perform duties as net control on the specified circuits. Positive and continuous circuit discipline is mandatory to prevent circuit inefficiency, confusion, or traffic delay. Idle chatter, profanity, and spurious transmissions are absolutely forbidden. It is the responsibility of the net control station to take corrective action during occurrences of violations.

Besides the responsibility for maintaining circuit discipline, the net control station is also charged with expediting the flow of traffic and limiting transmission to the essential minimum. The net control station must assume the responsibility of resolving disputes during the process of message handling and determining corrective action if a procedural discrepancy occurs. The authority of the net control station extends only to net operations within its scope of authority, and, in this regard, all decisions of the net control station are final. The net control station does not have jurisdiction over the administration of individual stations within the net.

Unauthorized Transmissions

Unauthorized transmissions, especially those of an obscene, indecent, or profane nature, project a lack of order and discipline in any net. Such transmissions will not be tolerated on any Navy circuits. The Federal Communication Act of 1934 states:

> "Whoever utters any obscene, indecent, or profane language by means of radio communications shall be fined not more than $10,000 or imprisoned not more than two years, or both."

As unauthorized and obscene transmissions are not usually accompanied by a call sign identification or personal identifying information, extra effort is utilized to identify the offending station. Part of this effort includes the use of tape recorders, accurate logs, notes of operator characteristics, exact frequency measurements, and direction finders (DF) to aid in proper identification. The monitoring is performed in accordance with the applicable OPNAV and SECNAV instructions governing unauthorized transmissions via Navy circuits.

Violation Reports

Any afloat unit or shore station noting a deviation from prescribed procedures should bring the violation to the attention of the violator by the use of Communications Improvement Memorandums (CIMs). In the event of continuing or flagrant violations, a speed letter report should be submitted to the fleet commander-in-chief, with copies to COMNAVTELCOM, the type commander, and the offending station. The report should include a description of the violation, publication reference, and the correct date/time of the violation.

FULL DUPLEX FSK SHIP/SHORE/SHIP (RFCS)

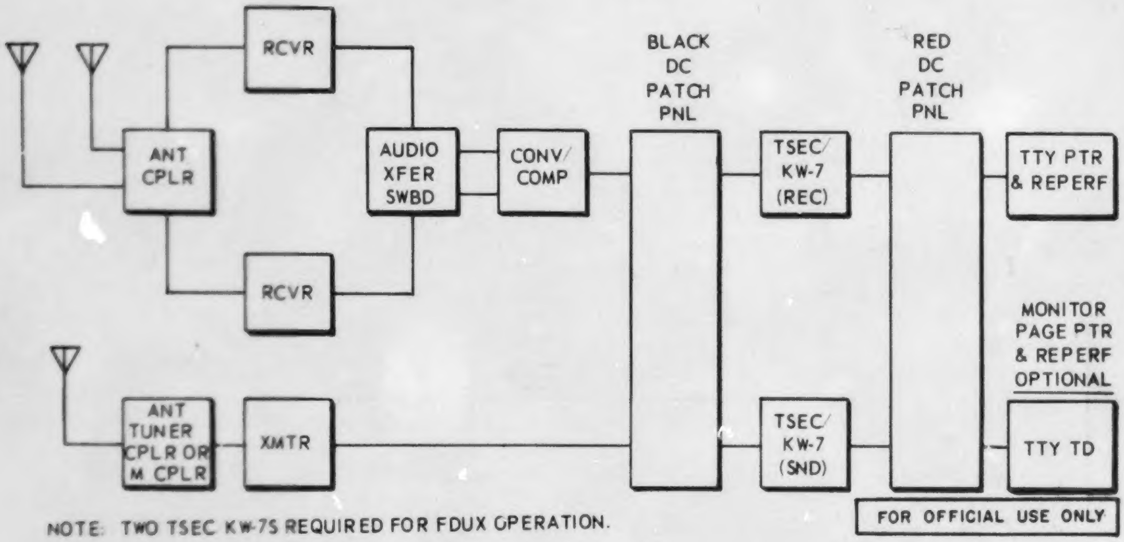
A full duplex FSK ship/shore/ship radio frequency carrier shift system (RFCS) covered by a TSEC/KW-7CR provides a ship with single channel full-period traffic capability. (FSK means frequency shift keying.) This ship/shore/ship system can be cleared to handle message traffic through the classification of Top Secret. Small ships traveling in company normally employ this system in a Task Group Common net in which they terminate with a larger ship (serving as net control) that, in turn, provides the ship/shore relay services. Ships traveling independently could use this system, or a modification of it, for an on-call ship/shore termination to transmit their outgoing traffic.

Figure 15-5 is a block diagram of the full duplex FSK ship/shore/ship system covered by a TSEC/KW-7CR. The diagram shows basically how the equipments should be connected to develop the system, but the block diagram for your ship may differ, depending on equipment or the way your equipment is wired into the patch panels.

Equipment Theory

The operator's section of each equipment technical manual is the local source you may consult to learn the operation of each equipment used in the primary ship/shore system. Here we will discuss basic information which can assist a Radioman in obtaining the best performance of the entire system.

TRANSMITTERS.—Some of the transmitters presently in use in the fleet which are compatible with this system are the AN/WRT-2, AN/URC-32, and the AN/URT-23. If the AN/WRT-2 is used, the operator should ensure the transmitter is in the FSK mode of operation and tuned to the exact center frequency (carrier frequency). When the AN/URC-32 transceiver is used as the transmitter for this system, the operator must adjust the transceiver dial frequency (suppressed carrier) to 2 kHz below the



NOTE: TWO TSEC KW-7S REQUIRED FOR FDUX OPERATION.

50.196

Figure 15-5.—Full Duplex FSK Ship/Shore/Ship RFCS.

assigned frequency. To use the AN/URT-23, the dial frequency must be set to the carrier frequency. Inside the equipment is a center frequency (CTR FREQ) switch which must be in the 2 kHz position. This switch is located on top of the FSK tone generator module.

RECEIVERS.—In this ship/shore/ship system it is possible to use any receiver capable of demodulating an FSK signal. The R-1051/URR is a versatile superheterodyne receiver capable of receiving radio signals in the 2 to 30 MHz frequency range. It can be used as an independent receiver, or in conjunction with a transmitter, and is basically crystal controlled. The R-1051 uses a digital tuning scheme, but an additional fine tuning control provides continuous tuning between 100 kHz increments. This receiver utilizes printed circuit boards and is completely transistorized, except for the RF amplifier tubes. The R-1051 is designated as standard equipment for ship/shore ORESTES and is the primary receiver now used for ship/shore communications.

CONVERTERS.—The AN/URA-17 frequency carrier shift converter-comparator group is used for diversity reception of RATT and FAX signals. The equipment consists of two frequency shift converters (a top and bottom unit). For either space diversity or frequency diversity reception, two standard Navy receivers are used in conjunction with the converter-comparator group. In space diversity operation, the two receivers are tuned to the same carrier frequency, but their receiving antennas are spaced some distance apart. Because of the required spacing between antennas, space diversity usually is limited to shore station use. In frequency diversity operation, the two receivers are tuned to different carrier frequencies that are carrying identical intelligence. Frequency diversity reception commonly is used aboard ship for copying the fleet broadcast which is keyed simultaneously on several frequencies. In diversity reception, the audio output of each receiver is connected to its associated frequency shift converter which converts the frequency shift into DC pulses. The DC (mark and space) pulses from each converter are fed to the comparator. In the comparator, an automatic circuit compares the pulses and selects the stronger of the two signals. The output of the comparator is patched to the teletype or the required crypto equipment. The converter units also can be used individually with separate teletypes to copy two different FSK signals. The AN/URA-17 is completely transistorized equipment and consists of two identical converter units. Each converter has its own comparator circuitry; therefore, a separate comparator unit is not required.

TELETYPE EQUIPMENT.—There are several different teletypewriters that may be used with this system. The equipment used generally is a matter of choice for the individual setting up the circuit. The teletype equipment that is selected should have its range finder set for optimum operation. The normal operating speed of Navy operated teletype equipment is 60, 75, or 100 words per minute. Gears located on the base of the equipment determine its speed.

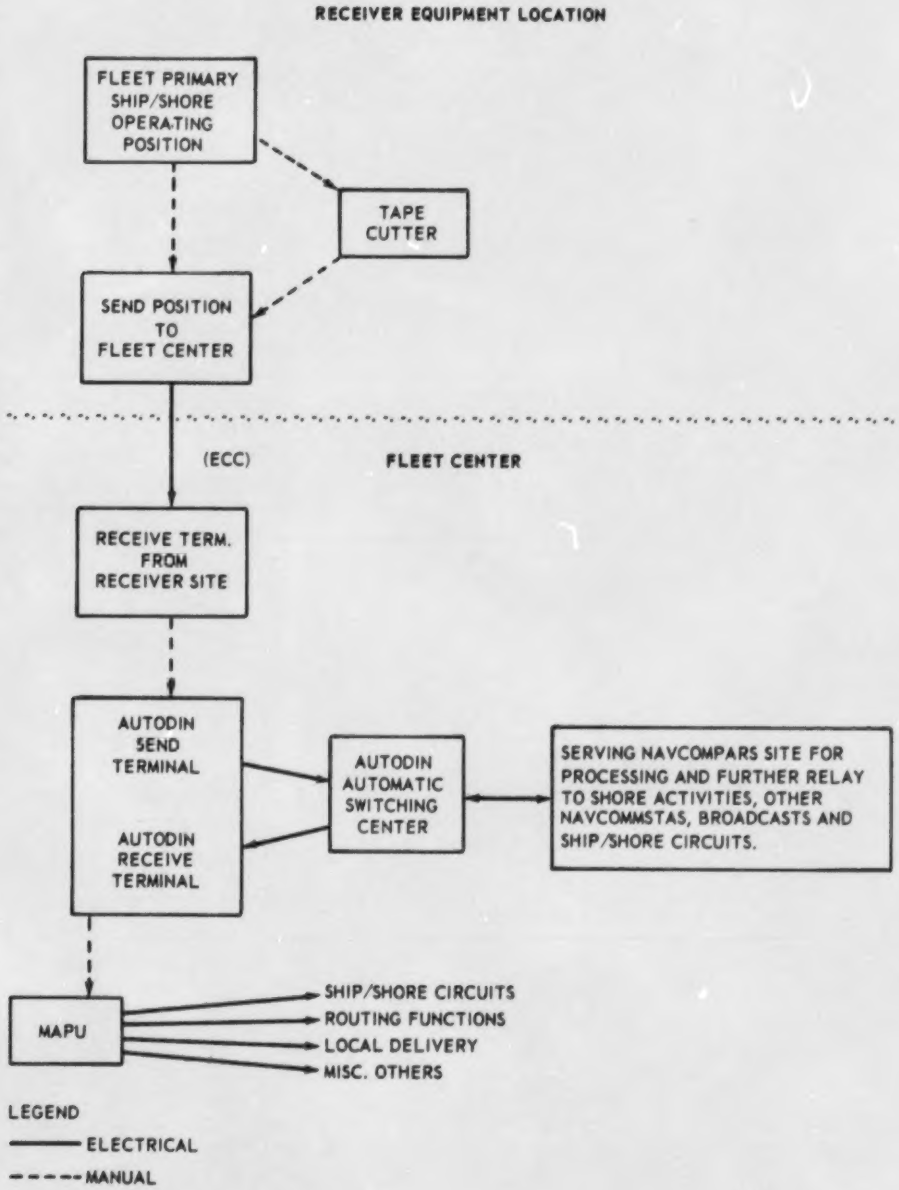
CRYPTO EQUIPMENT.—In full duplex ship/shore operation, a separate TSEC/KW-7CR is needed for each communication channel. The TSEC/KW-7CR is a simplex device which can operate either send or receive, but not both simultaneously. ORESTES is the mythological designator for the TSEC/KW-7CR crypto system. Operating instructions are contained in KAO 83. The ORESTES system may be used to pass traffic up to and including Top Secret and is used by all U. S. Forces and some Allied Navies. It is the primary means used by the Navy to pass ship/shore message traffic and may be used for FSK or tone modulated (TONE MOD) operation. The TSEC/KW-7CR is now equipped with a card reader mounted on the front of the gear (the "CR" portion of its designator means "card reader"). The card reader that was installed in Navy TSEC/KW-7CR equipments in the 1976/1977 time frame now enables operators to conduct daily restarts at the new crypto day in a matter of seconds by simply taking out the old card and replacing it with a new card in the card reader.

KEYLISTS.—Ship/shore keylists are issued in card booklet form, thirty-four cards to a book. There is one card numbered for each day of the month. The extra numbered cards each month are designated for emergency use, implemented by the controlling authority of the keylist. The complete book of key cards may be issued to operating personnel to be listed on the watch-to-watch inventory. Each superseded card must be destroyed within 72 hours of its supersession. Covers, instructional sheets, and extra emergency cards should be destroyed with the last operational card in accordance with the guidelines set forth in CMS 4 (series).

Traffic Flow

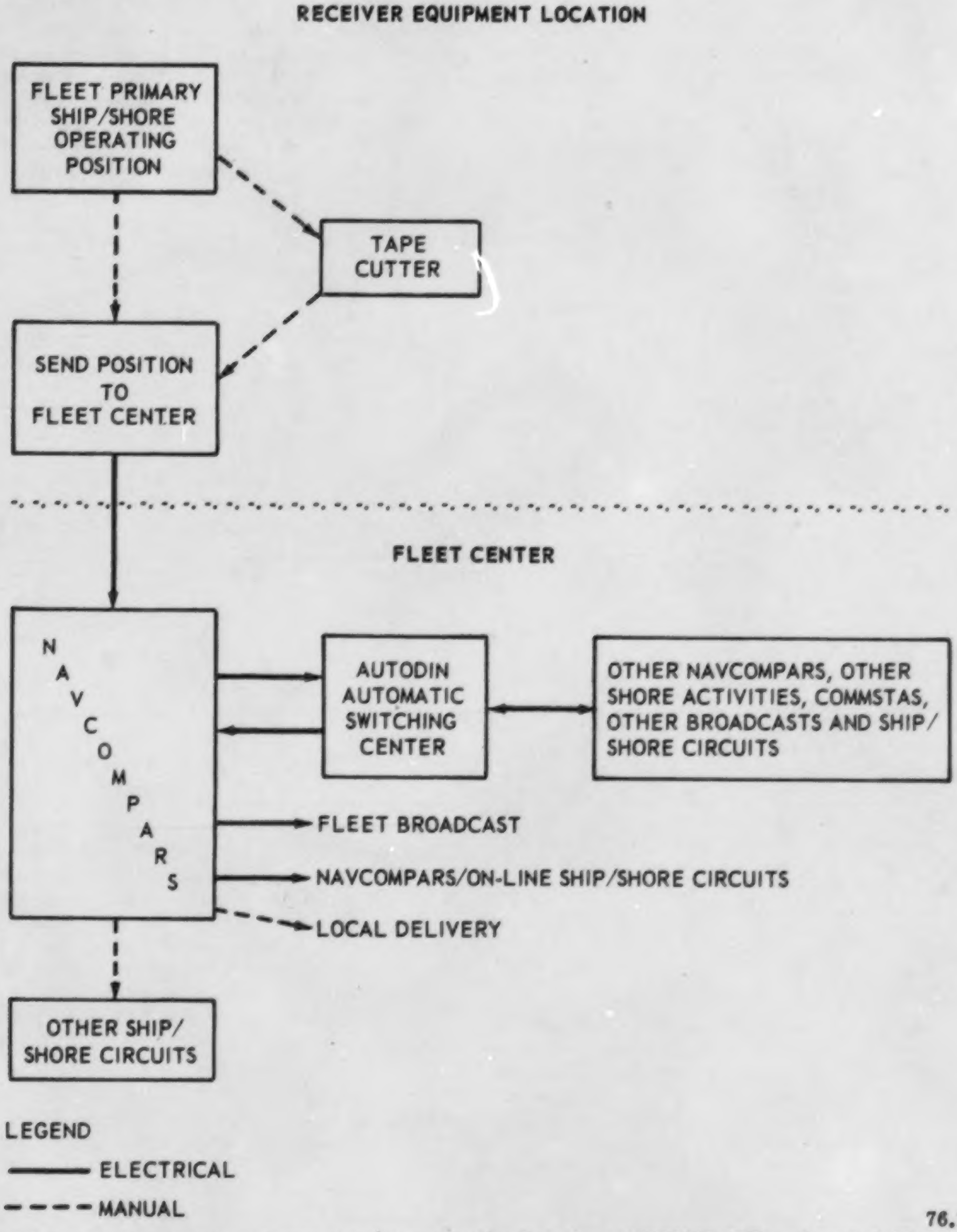
Figures 15-6 and 15-7 illustrate traffic flow from time-of-receipt (TOR) of messages received on fleet primary ship/shore circuits for delivery to either a NAVCOMPARS or AUTODIN interfacing system. Figure 15-6 shows traffic flow for a non-NAVCOMPARS equipped station, while figure 15-7 shows the traffic flow for a NAVCOMPARS equipped station.

NAVCOMPARS and AUTODIN have become the primary and often the only means by which


RECEIVER EQUIPMENT LOCATION
FLEET PRIMARY SHIP/SHORE OPERATING POSITION
TAPE CUTTER
SEND POSITION TO FLEET CENTER
(ECC)
FLEET CENTER
RECEIVE TERM. FROM RECEIVER SITE
AUTODIN SEND TERMINAL
AUTODIN RECEIVE TERMINAL
AUTODIN AUTOMATIC SWITCHING CENTER
SERVING NAVCOMPARS SITE FOR PROCESSING AND FURTHER RELAY TO SHORE ACTIVITIES, OTHER NAVCOMMSTAS, BROADCASTS AND SHIP/SHORE CIRCUITS.
MAPU
SHIP/SHORE CIRCUITS
ROUTING FUNCTIONS
LOCAL DELIVERY
MISC. OTHERS
LEGEND
ELECTRICAL
MANUAL

76.147

Figure 15-6.—Fleet primary ship/shore traffic flow for non-NAVCOMPARS equipped stations.


RECEIVER EQUIPMENT LOCATION
FLEET PRIMARY SHIP/SHORE OPERATING POSITION
TAPE CUTTER
SEND POSITION TO FLEET CENTER
FLEET CENTER
NAVCOMPARS
AUTODIN AUTOMATIC SWITCHING CENTER
OTHER NAVCOMPARS, OTHER SHORE ACTIVITIES, COMMSTAS, OTHER BROADCASTS AND SHIP/SHORE CIRCUITS
FLEET BROADCAST
NAVCOMPARS/ON-LINE SHIP/SHORE CIRCUITS
LOCAL DELIVERY
OTHER SHIP/SHORE CIRCUITS
LEGEND
ELECTRICAL
MANUAL

76.148

Figure 15-7.—Fleet primary ship/shore traffic flow for NAVCOMPARS equipped stations.

messages received on ship/shore circuits can be delivered to addressees and/or relayed to other NAVCOMMSTA for delivery by broadcast and ship/shore circuits. The reliability and speed-of-service of AUTODIN have been proven, and the automated message handling capabilities of NAVCOMPARS are further decreasing writer-to-reader times and manual message processing requirements.

Messages transmitted on fleet primary ship/shore circuits are in modified ACP 126 format. Due to propagation factors, afloat units may be required to make multiple transmissions to enable the NAVCOMMSTA to obtain a complete message. Therefore, messages may require further processing (or fixing) by the fleet primary ship/shore operators at the shore station to permit introduction of the messages into NAVCOMPARS/AUTODIN.

Messages (both tapes and page copy) transmitted on electronic courier circuits from receiver site buildings must be in correct and proper format, ready for introduction into AUTODIN or NAVCOMPARS without further processing. At non-NAVCOMPARS equipped stations, errors in the critical format line cause the Automatic Switching Centers to reject the messages or to generate service messages informing the AUTODIN subscribers of errors. At this point, manual processing, such as tape fixing or service action, will be required. Other common errors, such as security mismatches and errors in end-of-message or start-of-message functions, also cause messages to be rejected. At NAVCOMPARS equipped stations, errors in critical format lines or security mismatches require manual intervention and service action at the NAVCOMPARS Visual Display Terminal (VDT), which unnecessarily delay message traffic.

SECONDARY SHIP/ SHORE CIRCUITS

Secondary ship/shore is a CW, unclassified circuit, terminating with U. S. Navy or other underway ships on assigned frequencies. Amplifying procedures on the use of CW and its elements are located in ACP 124, ACP 121, ACP 131, ACP 100, and ACP 113. Familiarization with these publications is important for all prospective CW operators.

As an unclassified circuit, secondary ship/shore can only pass classified messages after they have been off-line encrypted. Otherwise, circuit operating procedures are very similar to those of the primary ship/shore circuits. The NAVCOMMSTA on the circuit is the net control station and should impose strict circuit discipline upon all circuit users. All coordination transmissions should be brief and to the point, using prosigns from ACP 124 and operating signals from ACP 131 to the maximum extent possible.

Although the advent of radioteletype circuits has made the delivery of message traffic more efficient, the requirement for CW circuits has not been completely eliminated. CW communications is the only way some smaller naval vessels have available to enter messages into the naval communications system. Additionally, many foreign vessels have only CW communications available for ship/shore and ship/ship use. Also, CW circuits exist as emergency and contingency means of communications to be utilized as the backup to ORESTES circuits.

The lack of CW use in the fleet has caused a continuing degradation of training CW operators. Whenever possible, advantage should be taken of in-port training circuits and formal CW training to expose new personnel to these circuits.

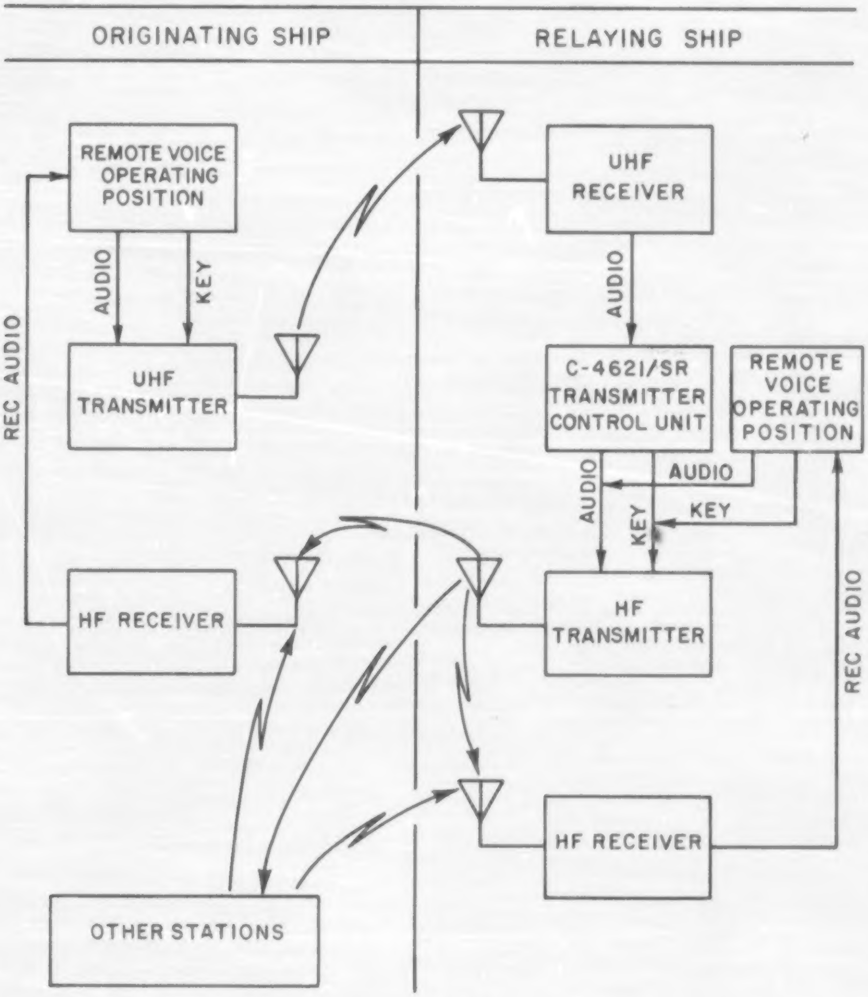
AUTOCAT AND MIDDLEMAN OPERATION

At times, certain emission control (EMCON) restrictions prohibit the transmission of radio frequency energy below the 30 MHz range. Therefore, there is a need for a technique to provide uninterrupted traffic flow without violating the restrictions of EMCON. AUTOCAT and MIDDLEMAN techniques were developed whereby the range of tactical UHF circuits may be extended by relay of the UHF circuit via HF. In MIDDLEMAN operation, an operator in an aircraft copies the transmissions from the ship on a UHF circuit and manually retransmits them via an HF circuit. In AUTOCAT operation, an aircraft is also used, but the communications equipment on board the aircraft receives the transmissions via UHF and automatically relays them via HF.

AUTOCAT and MIDDLEMAN can utilize three different types of circuit configurations for reception and relay of UHF transmissions. One is a voice circuit where some units send and receive on one frequency, and other units send and receive on any other frequency. Another is a voice circuit where all units transmit on one frequency and receive on another frequency. The third way is a RATT circuit where all units transmit on one frequency and receive on another frequency.

UHF/HF RELAY

The UHF/HF relay method has been developed to permit long range uninterrupted communications during periods of hazardous electromagnetic radiation (HERO). Typically, when an aircraft carrier is arming aircraft on board, HF transmitters must be shut down to prevent possible detonation of the ordnance. In order to maintain its ship/shore communications, the carrier transmits to a relay ship via a UHF circuit. The relaying ship then retransmits the signal on an HF frequency circuit to a terminated NAVCOMMSTA. An example by block diagram of a simple UHF/HF voice relay circuit is shown in figure 15-8. On-line radioteletype may be relayed as well as voice utilizing this system. Specific instructions for technical procedures in this system can be found in NTP 4.


ORIGINATING SHIP
RELAYING SHIP
REMOTE VOICE OPERATING POSITION
AUDIO
KEY
UHF TRANSMITTER
REC AUDIO
HF RECEIVER
OTHER STATIONS
UHF RECEIVER
AUDIO
C-4621/SR TRANSMITTER CONTROL UNIT
REMOTE VOICE OPERATING POSITION
AUDIO
AUDIO
KEY
KEY
HF TRANSMITTER
REC AUDIO
HF RECEIVER

76.149

Figure 15-8.—UHF/HF voice relay.

PIGEON POST

Another means of transmitting or receiving message traffic during a period of EMCON is called Pigeon Post. This is a term heard often throughout the Navy, but the procedure is seldom used. Pigeon Post involves physical transportation of messages via aircraft. In this operation, the messages are prepared in the form of precut teletypewriter tapes. The tapes are cut and placed in bags with an inventory listing each message tape. The bags are flown ashore to a message center (COMMSTA, NTCC) via aircraft, providing an efficient and reliable means of point-to-point transmission. The time of arrival at the message center is the time of delivery (TOD) of the message traffic from the originator.

This procedure requires advance notification to the COMMCENTER because of the requirements to arrange aircraft flights and set-up time at the shore based message center. The communications center should arrange for a messenger to meet the aircraft and pick up the traffic from the ship. After the communications center has received the messages, the center should send the ship a message acknowledging the messages. This message should provide the ship a time of delivery (TOD).

FLEET FLASH NET (FFN)

The Fleet Flash Net is a duplex TSEC/KW-7CR covered Top Secret teletype net. It operates at 100 words per minute. The net is composed of Fleet Commanders in Chief, numbered Fleet Commanders (COMSEVENTHFLT, COMFIRSTFLT, etc), and Task Force Commanders. Other commands may be designated to subscribe to the net as controlled by the Fleet Commander in Chief.

A command may be accessed to the Fleet Flash Net via landline, cable, or ship/shore circuit with a NAVCOMMSTA. The circuit may be extended to the Fleet Flash Net technical control console where it is connected to the other net members. The console is configured so that the technical control console operator can switch net members into the net after he receives a signal from the net member. The circuit is normally configured so that all stations on the net receive all traffic sent by all subscribers, although transmissions may be on a selective basis, depending on the needs of the calling station.

The main purpose of the Fleet Flash Net is to provide communications between operational command subscribers. Normally, all messages transmitted on the Fleet Flash Net are of FLASH or IMMEDIATE precedence. However, a PRIORITY message of extreme importance may be sent if circuit conditions permit. Messages on the Fleet Flash Net should contain no more than fifteen addressees and should be limited to no more than 150 groups. All transmissions on the net are preceded by a TSEC/KW-7CR phasing signal, which is the signal to the technical control console operator to switch the calling station to all other stations on the net.

The signal of the calling station will be routed through all subscribers of the net and back to the calling station. This route-back procedure is known as "hubbing." When the calling station receives its own signal back on its "receive" TSEC/KW-7CR, it is an indication that the proper connection has been made. Then, the calling station may proceed with its traffic. NTP 4 contains more information concerning the Fleet Flash Net. Detailed information may be found in NAVTELCOMINST C2303.6 (series).

INTERIM COMMAND SWITCHBOARD (ICSB)

The Interim Command Switchboard (ICSB) is a manually operated interface between voice radio circuits and telephone systems ashore. ICSB (formerly called NORATS) can utilize HF or UHF frequencies. Because these frequencies are open to exploitation or enemy interception, ICSB is restricted to unclassified communications of an official nature. Its main purpose is to provide voice communications between naval commanders and their subordinates by ship/shore or air/ground radio facilities. The switchboards are government owned overseas and commercially leased within CONUS.

Interim Command Switchboards are installed at selected NAVCOMMSTAs, where a call received from forces afloat and airborne forces can be manually switched to local commercial lines, AUTOVON, or other voice radio facilities. If a call is interfaced to commercial lines involving tolls, the NAVCOMMSTA transferring the call pays the cost, using available operations funds. Only official calls from fleet or airborne forces received by an ICSB may be transferred to commercial lines involving tolls. Personal calls involving tolls are not handled through ICSB.

Ship to Shore ICSB

A call on the ICSB is processed according to the precedence assigned by the originating party. A ship should initiate a call in the following manner:

"ICSB THIS IS (SHIP NAME) OVER"

After the ICSB operator replies, the ship then provides the ICSB operator with the precedence of the call, the phone number (if known), and the name and activity of the party being called. The ICSB operator may complete the call on the same frequency as the call-up was made or may inform the ship to switch to a more suitable working frequency.

Shore to Ship ICSB

If a shore activity desires to communicate with a ship via the ICSB, the shore activity should call the ICSB and inform them of what ship they desire to communicate with. The ICSB should then send a message to the ship via the appropriate broadcast informing the ship to communicate with the ICSB for a call. The ship then should attempt to communicate via any assigned ICSB frequency for the completion of the call.

ICSB Frequencies

Frequencies for use in the ICSB network are assigned by the cognizant Fleet Commander in Chief and promulgated by the COMMAREA NAVCAMS in Communicati[illegible]formation Bulletins (CIBs). If the frequencie[illegible] not provided or not held, they may be obtained via the Navy High Command World-Wide Voice Network (HICOM), primary ship/shore, or a full period termination. If the frequencies available are overloaded or not clear enough for traffic quality, additional frequencies can be made available through coordination with the NAVCAMS concerned.

ICSB Security

It is reasonable to assume that the ICSB frequencies are monitored occasionally. There is no voice security equipment provided in the ICSB system. It should be stressed to all users of the ICSB, therefore, that conversations conducted via this network should be limited to UNCLASSIFIED information.

NAVY HIGH COMMAND WORLD-WIDE VOICE NETWORK (HICOM)

The HICOM is an HF, single sideband network consisting of three separate voice nets on an area basis for world-wide coverage. The Chief of Naval Operations (CNO) has direct control over the HICOM network. As Fleet Commanders in Chief, CINCLANTFLT, CINCPACFLT, and CINCUSNAVEUR maintain positive control over the three individually assigned nets. The Area Control Station is operated by the appropriate Fleet Commander-in-Chief, or the communications station serving his headquarters may be assigned the responsibility. In either case, the operational control remains with the Fleet Commander-in-Chief.

HICOM Net Membership

The membership of the net can be controlled by CNO or the Fleet Commander-in-Chief. Numbered fleet commanders, designated subordinate commanders, aircraft carriers, cruisers, and command ships are required to maintain a continuous guard on HICOM. In addition, naval aircraft with VIPs embarked and ships operating independently under special circumstances maintain a guard on the net. Any ship, station, or activity may be designated to become a member of the net at the discretion of the CNO or the Fleet Commander-in-Chief.

Temporary Membership of HICOM

Units desiring to enter the net temporarily must obtain permission from the appropriate control station, specifying the length of time and purpose for entering the net. All ships, stations, and aircraft must be prepared for the requirement to communicate via HICOM, if directed. If equipment is available, it is a good idea for a ship to reserve one transmitter and receiver in a "standby" status set on the appropriate HICOM frequency to avoid time delays when the requirement exists.

HICOM Net Operation

Transmitter tuning is not permitted on the HICOM net. The transmitters should be pretuned and calibrated in a dummy load. Final tuning can be completed during live transmissions. Logs should be maintained if a continuous guard or listening watch is kept. The net may be utilized for unclassified FLASH or IMMEDIATE precedence operational voice traffic. This may include ship/shore/ship communications coordination information in an emergency but only after other means to effect restoration of the circuit path concerned have been exhausted. ACP 125 voice procedures should be employed on the net. Under normal conditions, the net should be notified by the control station at least five minutes prior to any impending frequency shifts. Amplifying rules of a particular net should be prescribed by the appropriate Fleet Commander-in-Chief.

HICOM Security

Due to the long period of the existence and long usage of HICOM the frequencies must be considered to be general knowledge available to foreign intelligence. Because the frequencies are assumed to be so well known, references to HICOM frequencies are always transmitted in plain language (in the clear). Encrypting these well known frequencies would tend to compromise the code used.

Authentication should be used to preclude deception. Maximum use should be made of secure voice circuits instead of HICOM when these voice circuits are available. Control stations should enforce strict circuit discipline over all transmissions. The established Fleet Commander's BEADWINDOW procedures must be utilized to ensure correct circuit operating procedures.

Call Signs

Shore stations should utilize their JANAP 119 call signs on the HICOM net. Ships should utilize their daily changing call signs, except when White Pinnacle Emergency Action Messages (EAMs) are submitted. Aircraft should use their bureau number (BUNO).

FLEET WARNING/ TACTICAL UHF NET

The Fleet Warning/Tactical Net (277.8 MHz) is guarded continuously by all U. S. Navy ships, except submarines when underway independently. If ships are traveling in a group, the net must be guarded by at least one of the units. Coast Guard cutters may use this net to communicate with Navy ships when required. The frequency has proven to be useful in communicating with other Navy ships for navigational purposes during periods of reduced visibility, particularly on entering or leaving port. The Navy also uses the frequency for local ship/shore harbor communications when required.

Uses of Fleet Warning/Tactical Net

The Fleet Warning/Tactical Net may be used in any of the following situations:

1. To establish communications between surface units or between surface units and aircraft.
2. For promulgation (by the SOPA) of urgent warnings of natural disasters.
3. To pass any emergency traffic.
4. To pass operational traffic when no common communications capabilities exist.

Guard and Operation of Net

Normally, the circuit is guarded on the bridge of a ship, either as a loudspeaker watch or with full transmit capability. Remote positions connected in CIC or main communications may be activated as ordered. The Fleet Warning/Tactical Net should be guarded by all submarines that are surfaced and in visual range of other fleet units. The net is reserved for operational or emergency voice traffic. Administrative traffic is not authorized on the Fleet Warning/Tactical Net.

FULL PERIOD TERMINATIONS

A "termination", as used in the communications community, is the connection of a circuit between two commands. A full period termination is one that is dedicated and keyed full-time between two commands on designated frequencies.

Senior operational commanders normally have a requirement to maintain a full period termination. Usually, criteria for maintaining a full period termination are based on the fact that traffic may exceed the speed and capability of a primary ship/shore circuit. These full period terminations may also be requested and maintained by other operational commanders and individual units during special deployments, exercises, or for training purposes.

Types of Terminations

There are basically two types of terminations. One is the single channel radioteletype (FSK) termination. The other is the multichannel radioteletype (VFCT) termination. Both of these terminations may utilize radio path transmission or, if the ship is in port, landline.

Termination Requests

Under normal conditions, the request to establish a full period termination should be sent to the appropriate NAVCAMS at least 48 hours prior to the desired activation time. If an emergency commitment exists, the request should be sent expeditiously to allow maximum preparation and coordination at the terminating NAVCOMMSTA. The message format for a termination request is outlined in NTP 4, and must be used as a guideline for the preparation of full period termination requests. When the request is received at the NAVCAMS, the ship normally is assigned to a specific NAVCOMMSTA by the NAVCAMS. The NAVCAMS also communicates with the ship to resolve any potential problems that may be encountered and coordinate the frequencies to be used on the termination.

Procedures

After local quality checks have been completed, the full period termination transmitters and receivers should be activated for a test between terminated activities. This test should take place approximately 30 minutes prior to the planned activation time. The receiving station controls the frequency shifts of the transmitting station at both ends. Therefore, if we have a ship and a NAVCOMMSTA terminated, the ship can instruct the NAVCOMMSTA to shift its transmitters from one frequency to another. The NAVCOMMSTA can also instruct the ship to change its transmitting frequency if the receive signal at the NAVCOMMSTA is not at traffic quality. The frequencies available for shift are provided in a list from the NAVCAMS (normally via Communications Information Bulletins). The circuit operating procedures for a full period termination are essentially similar to those of a primary ship/shore net. The exception in the case of full period terminations is that an operator does not have to wait his turn to transmit outgoing traffic with other stations on the net. The termination is between the ship and a NAVCOMMSTA with no one else on the frequency. The majority of the incoming traffic of the ship will also be received via the termination instead of the fleet broadcast. The ship will be assigned a seven-letter routing indicator: The first four letters derived from the NAVCOMMSTA terminated, the last three consisting of the last three letters of the international call sign of the ship. Hence, if the USS TRENTON (LPD14) (NEDG) is terminated with NAVCOMMSTA PONCE PR (RULGSAA), the routing indicator of the ship is "RULGEDG."

Single Channel (FSK) Terminations

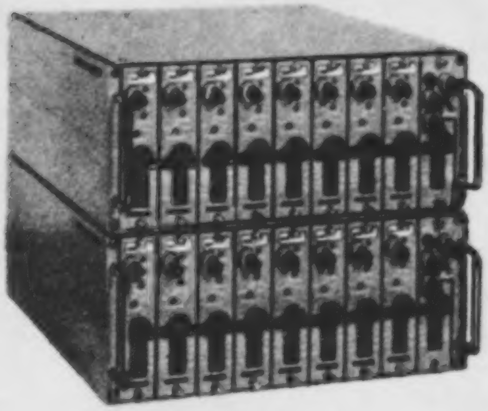
A single channel, full period termination on board ship should be set up as shown previously in figure 15-5. The circuit is cryptographically covered by TSEC/KW-7CR equipment. Two teletypewriter machines are dedicated to the circuit: One for transmit and one for receive. The crypto gear must be tested back-to-back prior to circuit activation. The shore station must test its channels going to and from the transmitter and receiver sites and check the complete circuit back-to-back off the air with a test from the fleet center. The shore station should use directional antennas whenever possible, and the technical control facility of the shore station must keep the transmitter and receiver sites informed of the position of the ship to provide proper antenna patterns.

VFCT Terminations

The number of communications networks in operation throughout any given communications area is increasing constantly. Until recently, each network was required to operate on a different frequency. As a result, the radio frequency spectrum became highly congested.

MULTIPLEXING.—The multiplex system is used to increase the message handling capacity of radio or teletypewriter channels and the transmitters and receivers associated with them. This increase in capacity is accomplished by the simultaneous transmission of several messages over a common channel. The frequency division multiplexing teletype terminal employs a number of tone channels, each slightly displaced in frequency.

TERMINAL EQUIPMENT.—The variable frequency carrier telegraph (VFCT) terminal normally used afloat on a multichannel ship/shore full period termination is the AN/UCC-1 shown in figure 15-9. At the transmitting station, the signals from the individual teletypewriters, known as channels, are multiplexed into one composite signal for transmission. The transmission with the multiplexed channels is known as a "tone package." At the receiving station, the composite signal (tone package) is demultiplexed (separated) into individual signals and distributed to separate teletypewriters, as required. The multichannel ship/shore configuration utilizing the AN/UCC-1 is known as the "P" system (VFCT). The basic number of channels is 16 in the U.S. Navy frequency division tone multichannel system, but separate systems may be set up with fewer channels, depending on the requirements of the volume of message traffic. A multichannel VFCT



120.26

Figure 15-9.—Telegraph Multiplex Terminal AN/UCC-1(V).

"P" system with three transmit and three receive channels is shown in figure 15-10. Many other illustrations of ship/shore systems are provided in NTP 4.

There are numerous types of VFCTs that can be employed on a full period termination, all of which are capable of transmitting and receiving from 1 to 16 channels. Among these are the AN/FGC-60, AN/FCC-67, AN/FCC-56, AN/FCC-37, and the AN/FCC-38. These VFCTs provide the means of minimizing the saturation of the frequency spectrum. Therefore, ships with the capabilities and requirements of a VFCT full period termination should utilize one whenever possible.

Circuit Outages and Restoration

There will always be occasions (especially in high frequency operation) when the messages on a circuit will be unreadable due to propagation factors. When the messages from a ship, for example, become unreadable or badly garbled, the shore station should log the circuit out and notify the ship to stop sending (QRT). The ship should then commence sending a test tape. At the shore station, the technical control takes over the circuit when it is logged out and has the responsibility of restoring the circuit to traffic quality. After the circuit has been restored, (by frequency shifts, tuning, etc.), the circuit is patched back to the traffic personnel who will notify the ship to resume sending traffic. Also, the technical control will notify the traffic section and the ship of the time the circuit was logged out, the time it was logged back in, the reason for outage (RFO), and any other pertinent information concerning the outage. If the circuit is logged out for more than one hour, a COMMSPOT report is submitted.

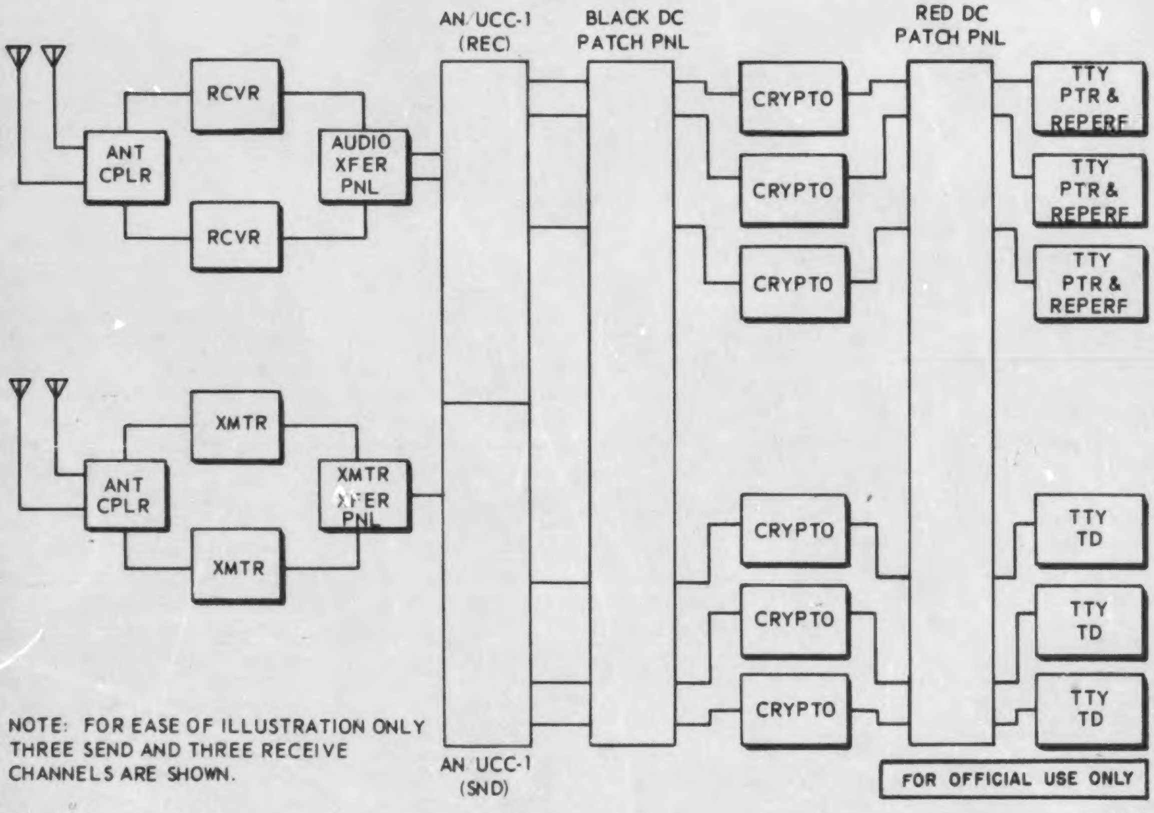
COMMSTAT/COMMSPOT Reports

Ships maintaining a full period termination are to submit COMMSTAT reports by priority message at 0001Z daily, unless otherwise directed by the Fleet Commander in Chief or the NAVCAMS. COMMSTAT reports are addressed for action to the appropriate NAVCAMS and information to the NAVCOMMSTA on the termination. The message provides information concerning outages on circuits during the previous radio day. The message also includes any broadcast outage of more than fifteen minutes, providing the frequencies copied during each six hour period of the day and the position of the ship at the time of the report.

COMMSPOT reports are submitted by all ships when any unusual communications difficulties are encountered. The COMMSPOT normally supplements information contained in the COMMSTAT report. Any ship may submit a COMMSPOT report if a special communications problem exists. For instance, a ship experiencing difficulty in copying all broadcast frequencies would send a COMMSPOT report to the area NAVCAMS reporting the problem and possible solutions. Examples of COMMSTAT and COMMSPOT reports are found in NTP 4.

RADIO EMISSION DESIGNATORS

Radio emissions are classified and symbolized to identify the bandwidth occupied, the type of modulation used, the type of transmission used, and supplementary information. An emission designator tells what type of transmission is authorized on a specific frequency. The designator is always used in the frequency usage report which is submitted by all operating forces of the Navy, Marine Corps, and all Navy shore activities transmitting on radio frequencies. OPNAVINST 2400.7 provides detailed information


AN/UCC-1
(REC)
BLACK DC
PATCH PNL
RED DC
PATCH PNL
RCVR
RCVR
ANT
CPLR
AUDIO
XFER
PNL
CRYPTO
CRYPTO
CRYPTO
TTY
PTR &
REPERF
TTY
PTR &
REPERF
TTY
PTR &
REPERF
XMTR
XMTR
ANT
CPLR
XMTR
XFER
PNL
CRYPTO
CRYPTO
CRYPTO
TTY
TD
TTY
TD
TTY
TD
NOTE: FOR EASE OF ILLUSTRATION ONLY
THREE SEND AND THREE RECEIVE
CHANNELS ARE SHOWN.
AN/UCC-1
(SND)
FOR OFFICIAL USE ONLY

50.197

Figure 15-10.—Multichannel Ship/Shore "P" System.

concerning the submission of the frequency usage report.

Below, we use the designator "3A3J" as an example and break it down into parts:

3—Necessary bandwidth (3kHz)
A—Type of modulation (Amplitude Modulation)
3—Type of transmission (Telephony)
J—Supplementary information (Single sideband suppressed carrier)

The parts of the emission designator are explained more in detail below.

BANDWIDTH

For a given class of emission, necessary bandwidth is the minimum bandwidth sufficient to ensure the transmission of information at the rate and with the quality required for the system employed. The required bandwidth is expressed as the first part of the designator in kilohertz (kHz). Formulas for finding bandwidths are very detailed and may be found in Annex A to NTP 6, the Navy Spectrum Management Manual.

TYPES OF MODULATION
OF THE MAIN CARRIER

The following is a list of types of modulation of the main carrier and the symbol used in the emission designation:

Type	Symbol
a. Amplitude	A
b. Frequency (or phase)	F
c. Pulse	P

TYPES OF TRANSMISSION

Here is a list of the types of transmission that may be utilized and their corresponding symbols:

Type	Symbol
a. Absence of any modulation intended to carry information	0
b. Telegraphy without the use of a modulating audio frequency	1
c. Telegraphy by the on-off keying of a modulating audio frequency or audio frequencies, or by the on-off keying of the modulated emission (Special case: an unkeyed modulated emission.)	2
d. Telephony (including sound broadcasting)	3
e. Facsimile (with modulation of main carrier either directly or by frequency modulated subcarrier)	4
f. Television (vision only)	5
g. Four-frequency diplex telegraphy	6
h. Multichannel voice-frequency telegraphy	7
i. Cases not covered by the above	9

SUPPLEMENTARY CHARACTERISTICS

Supplemental characteristics are added as the last item of the emission designator. A list of the supplemental characteristics and their symbols is shown below:

Characteristic	Symbol
a. Double sideband	(none)
b. Single sideband -	
Reduced carrier	A
Full carrier	H
Suppressed carrier	J
c. Two independent sidebands	B
d. Vestigial sideband	C
e. Pulse -	
Amplitude modulated	D
Width (or duration) modulated	E
Phase (or position) modulated	F
Code modulated	G

Representative Emission Designators

The emission designators listed in Table 15-1 are examples of those used by the U.S. Navy.

Some of the bandwidth calculations are now under study by the International Radio Consultative Committee (CCIR) of the International Telecommunications Union (ITU) and will probably be revised at a future conference.

More detailed information concerning frequencies and their emission designators may be found in NTP 4 and Annex A to NTP 6.

TRANSMITTER AND RECEIVER TUNING

All transmitters and receivers should be calibrated to the frequencies called for in the appropriate frequency plans. During the calibration, the antennas should be grounded and the transmitter should be tuned through all stages preceding the antenna stage. When the final tuning is completed using the antenna stage (on the air), the lowest possible power should be utilized. Usually, it is a good idea that antenna tuning below 15 MHz be done around midday, and antennas for frequencies between 15 and 30 MHz be tuned after darkness. VHF and UHF transmitters may be tuned during daylight hours. The operator should remember to monitor the frequency desired prior to tuning on it, due to the possibility of interfering with communications in progress on that frequency.

The frequency of radio receivers (except crystal controlled receivers) on circuits with no or few transmissions must be checked with a frequency meter at least every four hours. After calibration, the frequency of shipboard transmitters that are not utilizing crystal controlled or stabilized master oscillators and that are being used frequently should be checked every four hours. A transmitter not in frequent use should be checked each time prior to transmitting. The frequency meters themselves should be checked at least once a week against the standard frequency broadcast, and a log must be maintained for the checks conducted.

TRANSMITTER TESTING

Transmitter testing aboard ship should not take place until due consideration has been given to the radiation characteristics of the frequencies being used. Also to be considered is the power being used and the fact that radio silence may be in effect. The senior officer present should control any transmissions made in port for test purposes.

Table 15-1.—Representative Emission Designators

DESIGNATOR	TYPE OF EMISSION	PROPER USAGE AND REMARKS
0.1A1	CW Manual Morse Telegraphy	Note (1)
0.28F1	60 WPM Single Channel RATT	Note (2)
0.3F1	100 WPM Single Channel RATT	Note (2)
0.6F1	60 WPM Single Channel RATT	Note (3)
1.08F1	60 WPM Single Channel RATT	Note (4) and (5)
1.24F1	100 WPM Single Channel RATT	Note (4) and (5)
1.24A7J	100 WPM 4 Channels SSB RATT	Note (6)
1.7A7J	100 WPM 8 Channels SSB RATT	Note (7)
1.7F1	60 WPM 4 Chnl Time Div RATT	Note (11)
2.04A2	1020 Hz Homer Beacon	Note (11)
2.85 F1	100 WPM 4 Chnl Time Div RATT	Note (11)
2.8A3J	Telephony (SSB)	Note (8)
3A3J	Telephony (SSB)	Note (8)
3A7J	100 WPM 16 Channels SSB RATT	Note (8)
3A9J	Simultaneous Telephony & RATT, Simultaneous Telephony & Data, all SSB	Note (8)
4F4	Facsimile	Note (9)
6A3	Telephone (DSB AM)	Note (1)
6A3B	Telephone (DSB AM)	Note (10)
6A7B	Dual SSB Multichannel Telegraphy	Note (10)
6A9B	Simultaneous operations as indicated for 3A9J emission	Note (10)
9A9B	Three 3 kHz Intelligence Channels for SSB voice, Telegraphy or Composite Transmissions	Note (8)
10A3	Telephony (DSB AM) Broadcast Quality	Note (11)
12A9B	Four 3 kHz Intelligence Channels for SSB Voice, Telegraphy and Composite Transmissions	Note (10)
16F3	Telephony (FM Narrow Band)	Note (1)
30F3	Telephony (FM)	Note (1)
36F3	Telephony (FM)	Note (1)
80F9	Multiplexed Telephony (FM)	Note (1)
120F9	Multiplexed Telephony (FM)	Note (1)

Note (1) Actual assigned frequency utilized for tuning transmitters; offsetting and rounding off procedures not employed.

Note (2) The AN/SGC-1 produces 700 Hz and 500 Hz mark/space tones.

Note (3) This designator indicates a radio frequency carrier shift of ±85 Hz (total 170 Hz shift) for mark/space signals. Equipment limitations may require VLF shore stations to place the mark signal on the assigned frequency and the space signal 50 Hz above the mark signal. When CW keying is utilized, the mark signal (assigned frequency) is keyed.

Note (4) The AN/WRT-2 type equipment produces 425 Hz tones in the LSB and USB to indicate a mark or a space signal. Therefore, the emission is centered on the suppressed carrier (dial) frequency with a ±425 Hz shift for mark/space signals. Note that the suppressed carrier frequency is the same as

Table 15-1. — Representative Emission Designators — Continued

the assigned frequency. The AN/WRT-2 will be used only when frequencies ending in whole kHz are employed due to the inability to tune the transmitter in other than whole kHz in the synthesized mode.

Note (5) The AN/URC-32, AN/ARC-94, AN/URT-23, AN/URT-24, AN/WRC-1 and the AN/SRC-23 type equipment produce 1575 Hz and 2425 Hz mark/space tones which are used to amplitude modulate the carrier before suppression. Subsequent suppression of the carrier, and elimination of the lower sideband, provides an emission which is centered on the assigned frequency, 2 kHz above the suppressed carrier (dial) frequency, with a ±425 Hz shift for mark/space signals. Note that the suppressed carrier (dial) frequency should be 2 kHz below the assigned frequency.

Note (6) (1.24A7J) This designator is assigned for single sideband, suppressed carrier, amplitude modulated emission with 1.24 kHz bandwidth and is authorized for multichannel operation for channels one (425 Hz) through five (1105 Hz) of the Navy Tactical Multi-Channel VFCT systems. However, the fifth channel (channel 5) will appear extremely close to the upper limit of the band clearance. For most terminations, four channels should suffice, with the fifth channel idled out but available for use if required. The suppressed carrier for proper radiation of this emission is as follows: For assigned frequencies ending in whole kHz, the carrier is off-set 1 kHz below the assigned frequency; for assigned frequencies ending in .5 kHz, the carrier is off-set .5 kHz below the assigned frequency. The transmitter is modulated utilizing USB operation.

Note (7) (1.7A7J) This designator is designed for single sideband, suppressed carrier, amplitude modulated emission with 1.7 kHz bandwidth and is authorized for multichannel operation for channels one (425 Hz) through eight (1615 Hz) of the Navy Tactical Multi-Channel VFCT systems. The suppressed carrier for proper radiation of this emission is obtained by subtracting .85 kHz from the assigned frequency and rounding off the resultant frequency (.01 through .05 kHz to the next lower tenth kHz and .06 through .09 kHz to the next higher tenth kHz). The transmitter is tuned to the resultant frequency obtained and USB operation is utilized.

Note (8) (3A3J, 3A7J, 3A9J, 9A9B, 2.8A3J) A single sideband, suppressed carrier, amplitude modulated emission occupying 3 or 9 kHz of the spectrum. 3A3J emission is authorized only for SSB telephony. 3A7J emission is authorized only for multichannel RATT. 3A9J emission is authorized only for simultaneous transmission of voice and data or data and telegraphy. (Alternate use of 3A3J or 3A7J emissions is not authorized for 3A9J transmissions.) Frequencies assigned 9A9B emission are authorized for transmission of three independent 3 kHz intelligence channels containing voice, multichannel telegraphy, and composite voice and data or data and telegraphy emissions. If all channels within a particular composite multichannel RATT signal are not keyed, the necessary bandwidth actually occupied by the multichannel signal will be dependent upon how many and which specific channels are used. Only the 3A7J designator should be used to indicate multichannel HF SSB emission. The suppressed carrier for proper radiation of 3A3J, 3A7J, 3A9J, and

Table 15-1.—Representative Emission Designators—Continued

9A9B emissions is obtained by subtracting 1.5 kHz from the assigned frequency and rounding off the resultant frequency (0.1 through 0.5 to the next lower whole kHz and 0.6 through 0.9 to the next higher whole kHz). The transmitter is then tuned to the frequency obtained and USB operation utilized for 3A3J, 3A7J, and 3A9J emissions. Both upper and lower sidebands are utilized for 9A9B emissions. 2.8A3J is authorized only for SSB telephony, occupying a bandwidth of 2.8 kHz. It is identical to the 3A3J emission except for transmitter tuning procedures. The suppressed carrier for proper 2.8A3J emission is obtained by subtracting 1.4 kHz from the assigned frequency and rounding off the resultant frequency as described above. The transmitter is tuned to the frequency obtained and USB operation is utilized.

Note (9) A 4 kHz frequency or phase modulated facsimile emission. The transmitter must be tuned 2 kHz below the assigned frequency for authorized transmission of a 4F4 emission.

Note (10) (6A3B, 6A7B, 6A9B, 12A9B) Dual sideband, suppressed carrier, amplitude modulated emissions occupying 6 or 12 kHz of spectrum. 6A3B emission is authorized for two independent 3 kHz voice channels. 6A7B is authorized only for two independent 3 kHz channels radiating multichannel telegraphy transmission. 6A9B emission is authorized only for two 3 kHz channels radiating composite transmissions as explained in the case of the 3A9J emission. 12A9B emission is authorized only for four independent 3 kHz channels radiating voice, multichannel telegraphy, or composite transmissions. The suppressed carrier for proper transmission of 6A3B, 6A7B, 6A9B, and 12A9B is the same as the assigned frequency.

Note (11) To ensure proper procedures are followed when transmitters are tuned for various emissions, operators must refer to appropriate technical or operator manuals for the equipment being utilized. All emissions must be centered on the assigned frequency. Those emissions which cannot be centered exactly on the assigned frequency due to equipment tuning limitations should be centered as closely as possible.

Transmitters ashore should be checked as frequently as is necessary to ensure correct adjustments to authorized frequencies and tolerances.

FLEET SATELLITE COMMUNICATIONS

Satellite Communications has given the Navy an expanded capability to meet increasing requirements of command, control, and the support of its operating forces. Communications satellites have become the primary over-the-horizon, point-to-point, ship-to-ship, ship-to-shore, shore-to-ship, and broadcast transmission systems. Navy tactical and strategic communications operate in the UHF and SHF frequency bands. The Navy also operates ground terminals in support of the Defense Satellite Communications System (DSCS.)

Satellite communications will not replace all existing means of radio communications; however, it is a major step in modernizing Navy communications and will relieve the Navy of its total dependence on HF radio transmissions.

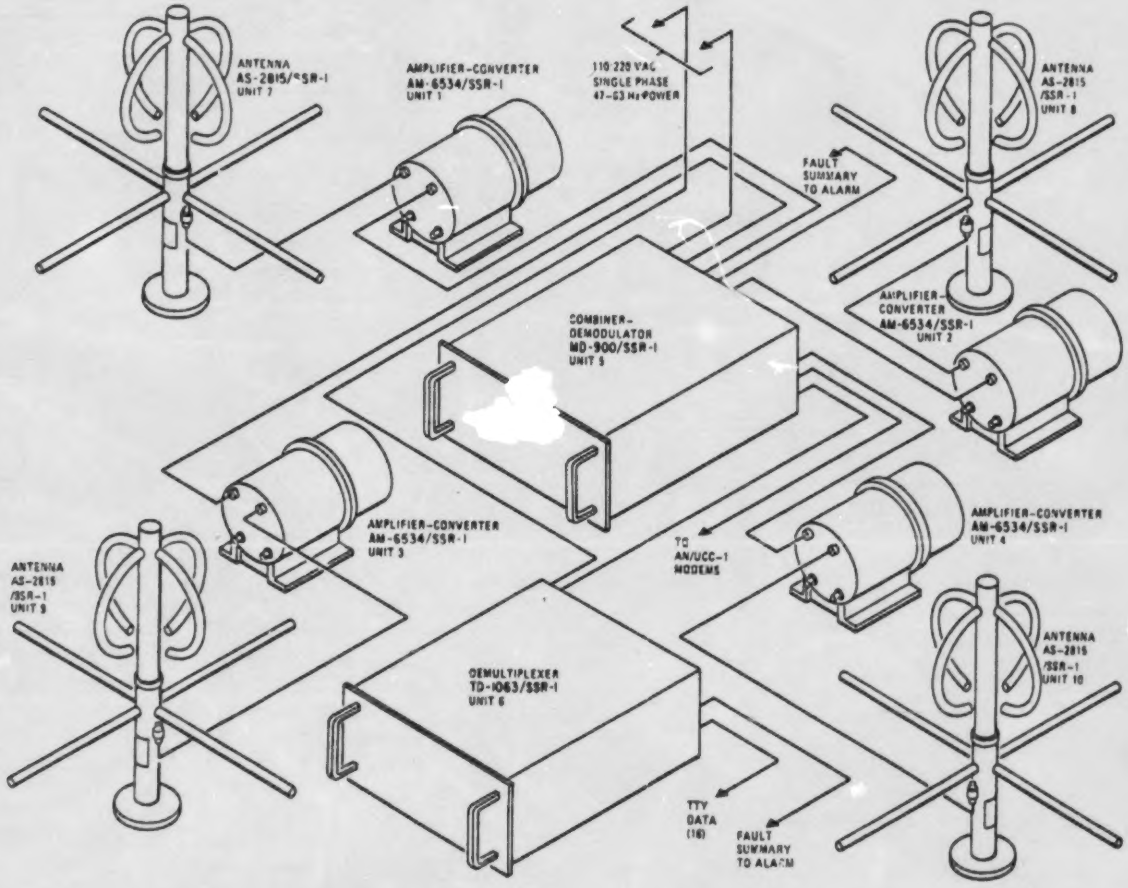
The Navy satellite systems are employed to the maximum extent possible within the lifespans of the spacecraft. Usage of frequencies, bandwidths, and power is established on a priority basis. The Naval Telecommunications Command has published specific operational procedures for the various satellites in NTP 2.

UHF SATCOM "N" SYSTEM

The UHF shipboard SATCOM "N" system is similar to the description of the Fleet Multichannel "N" System for LF/MF/HF previously discussed, except for the type of reception and the receiver (AN/SSR-1) used. The function of the AN/SSR-1 is to receive fleet multichannel teletypewriter broadcasts which are transmitted from a ground station and relayed to naval vessels by satellite. The receiving system consists of four antennas and amplifier-converter units, a combiner-demodulator unit, and a demultiplexer unit. The antenna and amplifier-converter units are mounted above deck, and the combiner-demodulator and demultiplexer are mounted in equipment racks in the radio spaces below deck.

Receive System Signal Flow

Refer to figure 15-11. In this system the transmitted carrier may be frequency modulation (FM) or phase-shift keyed (PSK) modulation. Selection of the applicable demodulation


ANTENNA
AS-2815/"SSR-1
UNIT 7
AMPLIFIER-CONVERTER
AM-6534/SSR-1
UNIT 1
110-220 VAC
SINGLE PHASE
47-63 Hz POWER
ANTENNA
AS-2815
/SSR-1
UNIT 8
FAULT
SUMMARY
TO ALARM
AMPLIFIER-
CONVERTER
AM-6534/SSR-1
UNIT 2
COMBINER-
DEMODULATOR
MD-900/SSR-1
UNIT 5
AMPLIFIER-CONVERTER
AM-6534/SSR-1
UNIT 3
ANTENNA
AS-2815
/SSR-1
UNIT 9
TO
AN/UCC-1
MODEMS
AMPLIFIER-CONVERTER
AM-6534/SSR-1
UNIT 4
ANTENNA
AS-2815
/SSR-1
UNIT 10
DEMULTIPLEXER
TD-1063/SSR-1
UNIT 6
TTY
DATA
(16)
FAULT
SUMMARY
TO ALARM

76.150

Figure 15-11. — Receiving Set, Satellite Signal AN/SSR-1 — relationship of units.

mode is accomplished manually by the operator at the AN/SSR-1 receiver. The receiving antennas for this system are positioned about the ship in such a manner (normally one in each quadrant of the ship) that at no time is the line-of-sight blocked between the relay satellite and one or more of the antennas. Each amplifier-converter is located within 10 cable-feet of its associated antenna. The IF signal from each amplifier-converter is routed below deck to the combiner-demodulator. The operating power and local-oscillator signal are coupled from the combiner-demodulator to each amplifier-converter via the same twin-axial cable used for the IF signal. Because of signal path variations, shading, and reflections, the four IF signals are subject to random phase and amplitude variations. The combiner operation performed within the combiner-demodulator removes the phase variations from each input signal, weighs the amplitudes of the signals for optimum combining, and then sums the signals. After being combined, the signal is demodulated and coupled to demultiplexing equipment. When the equipment is operating in the FM mode, the output of the combiner-demodulator is coupled via the receiver transfer switchboard to the AN/UCC-1. The remaining portion of the system is the same as that described for the LF/MF/HF "N" system.

For more information on Satellite communications, refer to NTP 2, Navy Satellite Operations.

CHAPTER 16

DISTRESS COMMUNICATIONS

To promote safety at sea and in the air, methods of communication have been developed for use in times of distress. Distress message traffic is best described as all communications relating to the immediate assistance required by a mobile station in distress. Distress traffic has priority over all other traffic. All Navy communicators should be familiar with distress signals in order to properly evaluate their meanings and take appropriate action when necessary.

If ships sailing independently become involved in a distress situation, the Radiomen onboard should send distress messages on normal operating encrypted circuits that are maintained while underway. If the need for assistance outweighs security considerations, the Navy ship may send an unclassified distress message on one of the national or international distress frequencies. When it is traveling in company with other ships, the ship in distress should transmit the distress message to the Officer in Tactical Command (OTC) who will take appropriate action.

Naval aircraft use normal tactical or airroute military/civilian circuits for distress communications. If difficulty exists while these circuits are being used for communications, the aircraft in distress should shift to one of the aircraft distress frequencies listed in the following section of this chapter.

DISTRESS FREQUENCIES

Several frequencies in different bands are designated for the transmission of distress, urgency, safety, or search and rescue (SAR) messages. All Radiomen must know the specific frequencies and understand their use.

The following frequencies have been designated for use during distress or emergency:

500 kHz—International CW/MCW distress and calling.

2182 kHz—International voice distress, safety and calling.

8364 kHz—International CW/MCW lifeboat, liferaft, and survival craft.

121.5 MHz—International voice aeronautical emergency.

156.8 MHz—FM United States voice distress and international voice safety and calling.

243.0 MHz—Joint/Combined military voice aeronautical emergency and international survival craft.

During search and rescue (SAR) missions, the following frequencies are authorized for use:

3023.5 kHz and 5680 kHz—International search and rescue frequencies for the use of all mobile units at the scene of a search and also for use of shore stations to communicate with aircraft proceeding to or from the scene of search. CW or voice emission is authorized.

123.1 MHz—International worldwide voice search and rescue use.

138.78 MHz—U. S. military voice search and rescue on-the-scene use. This frequency is also used for direction finding (DF).

172.75 MHz—U. S. Navy emergency sonobuoy communications and homing use. This frequency is monitored by all U. S. Navy ASW aircraft while assigned to a SAR mission.

282.8 MHz—Joint/Combined on-the-scene voice and direction finding (DF) frequency used throughout NATO.

Note that 500 kHz is used in times of distress, and it also is the international calling frequency. In routine radiotelegraph communications, merchant ships contact each other on 500 kHz and then shift to a "working" frequency. To make sure that other uses of 500 kHz will not interfere with distress traffic, two silent periods are designated. These periods are for 3 minutes each, beginning 15 minutes after each hour and 15 minutes before each hour (X:15 and X:45.)

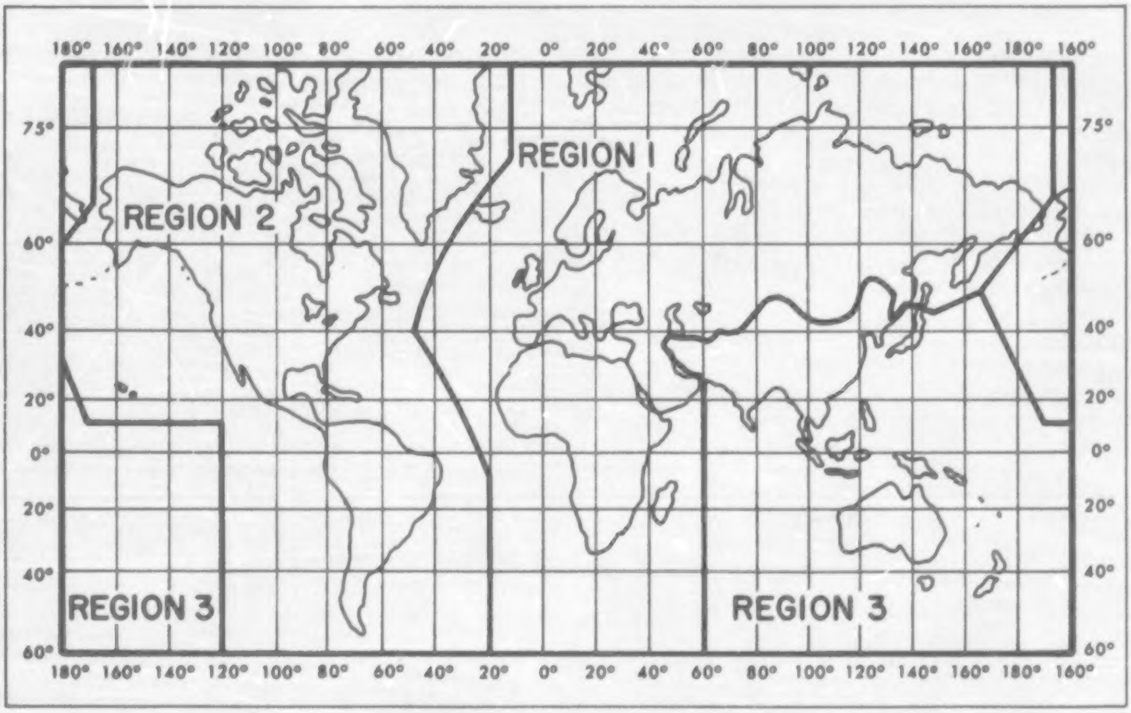
Ship clocks in radio spaces usually have these 3-minute segments of the clock face painted red to remind operators of silent periods to be observed. Except for actual distress messages, all traffic ceases at these times on frequencies between 480 kHz and 520 kHz. This procedure is applicable in all International Telecommunications Union (ITU) regions of the world. (See figure 16-1.)

The control of distress message traffic on any of the designated frequencies is the responsibility of the station in distress, but this station may delegate its responsibility to another station on the frequency. In distress cases involving civil aviation, the control of the distress traffic is the responsibility of the station addressed in the distress message.

The station in control of the distress traffic on a distress frequency may impose silence on all stations using the frequency or on any station interfering with the distress traffic. The form of the signal sent via CW is "QRT SOS," and the voice signal is "STOP TRANSMITTING—MAYDAY."

DISTRESS WATCHES AFLOAT

Navy units at sea have always practiced the tradition of maintaining listening watches on distress frequencies. At a minimum, a listening watch should be kept on 500 kHz during working hours. For ships copying one-operator periods on a Fleet Composite Broadcast, working hours are considered to be the same times of the day the broadcast is copied. For ships with two or more broadcast operators, working hours are considered to be continuous. Whenever personnel and equipment conditions permit, a continuous guard or cover should be maintained on 121.5 MHz and 243.0 MHz, with a listening watch kept on 8364 kHz. The commanding officer of a ship traveling independently or the officer



76.154

Figure 16-1.—ITU World Regions.

in tactical command (OTC) of ships in company should ensure these watches are kept, providing that transmitting and receiving equipments are available. If the commanding officer or the OTC believes that maintaining these watches will interfere with the military effectiveness of the ship(s), he may exempt the watches. The OTC of ships in company may also divide the distress frequencies among the ships in his group so that all frequencies are covered and no single ship is tasked with the entire distress frequency guard.

METHODS OF TRANSMISSION

The components of distress message traffic include the alarm signal, the distress signal, the distress call, and the distress message. Figure 16-2 describes the composition of each component.

Any station that hears a distress call must immediately cease all transmissions capable of interfering and continue to listen on the frequency on which the distress call was heard. The call-up in distress traffic is normally a general call and is not addressed to any particular station. The distress message must be repeated at intervals, especially during the periods of silence. The alarm signal also may be repeated, if necessary. There must be an interval of time between the transmission of the alarm signal and the distress message to allow stations preparing to reply to operate their transmitters.

If a ship or aircraft in distress receives no answer to its distress message on a distress frequency, the message may be repeated on any other available frequency on which attention may be attracted. Immediately prior to the total abandonment of a ship/aircraft and before a crash landing of an aircraft, the radio equipment on board should be set for continuous emission.

ACKNOWLEDGING RECEIPT

A mobile station (a ship underway) which learns that another mobile station is in distress may transmit a distress message if the station in distress is not in a position to transmit the message. Also, a station that is not in distress and is not in a position to lend assistance may transmit the distress message. This may be done when this station has heard a distress message that has not been acknowledged or when the unit that intervenes believes more help is necessary.

Stations that receive a distress message from a mobile station which is definitely in their vicinity must immediately acknowledge receipt. This rule is flexible, depending on the capability of the transmitter at the receiving station and whether or not radio silence periods are in effect. Care must be taken to avoid interfering with the acknowledgement transmissions that are being sent by other stations.

Stations of the mobile service which receive a distress message from a mobile station that is definitely not in their vicinity must allow a short interval of time before acknowledging receipt of the message. This is to permit the possibility of a station nearer to the distressed station to answer and acknowledge receipt without undue interference.

The message format for acknowledging receipt of a distress message is shown in figure 16-3.

FOLLOW-UP MESSAGES

Every mobile station which acknowledges receipt of a distress message must, on the order of the commanding officer, transmit as soon as possible the following information in the order shown:

1. Its own identification.
2. Its own position.
3. The speed at which it is proceeding towards the mobile station in distress, and the approximate time it will take to arrive at the position of the distressed station.
4. The true bearing of the unit in distress, if available, when the position appears doubtful.

When the follow-up message is sent, caution must be exercised to ensure that the transmission of this message does not interfere with other stations that are better situated to communicate with, and lend assistance to, the station in distress.

CESSATION OF DISTRESS TRAFFIC

When the distress traffic has been completed or when silence on the frequency used for distress traffic is no longer required, the station which has the control of the distress traffic should transmit a message addressed to all stations, indicating that normal traffic may

	COMPONENTS OF DISTRESS TRAFFIC	
Component	Description	Composition
Alarm Signal	Precedes the distress call to operate automatic alerting equipment. In radio telegraphy the alarm signal is followed in order by the distress call, an interval of two minutes, the distress call again and the distress message. In radio telephony the alarm signal (whenever possible) is followed in order by the distress call and the distress message.	CW: A series of 12 dashes sent in one minute. Each dash is 4 seconds long with a 1 second interval in between. Voice: Two sinusoidal audio-frequency tones, one of 2200 Hz and the other 1300 Hz transmitted alternately. Each tone is 250 milliseconds long.
Distress Signal	Indicates that the unit sending the signal is threatened by grave or imminent danger and requests immediate assistance. It must be sent before the call and at the beginning of the preamble of any distress message.	CW: $\overline{\text{SOS}}$ Voice: "MAYDAY"
Distress Call	Combines the DISTRESS SIGNAL with the call sign of the calling station. It is sent only on the authority of the person in command of the unit carrying the mobile station. Has absolute priority over all other transmissions. It must not be addressed to a particular station nor is acknowledgement or receipt to be given before the distress message which follows it is sent. All stations hearing the DISTRESS CALL must immediately cease any transmission capable of interfering with the distress traffic. They shall continue to listen on the frequency used for emission of the DISTRESS CALL.	CW: 1. DISTRESS SIGNAL $\overline{\text{SOS}}$ transmitted three times. 2. Prosign DE. 3. The call sign of the mobile station in distress, sent 3 times. Voice: 1. DISTRESS SIGNAL "MAYDAY" spoken three times. 2. Proword "THIS IS" (in case of language difficulty DE, spoken DELTA ECHO, may be used). 3. Call sign or other identification of the mobile station in distress spoken three times.
Distress Message	Gives the details of the distress situation. Must follow the DISTRESS CALL as soon as possible.	1. The distress signal "$\overline{\text{SOS}}$" or "MAYDAY" 2. Name or other identification of the ship, aircraft or unit in distress. 3. Particulars of its position*, the nature of the distress, and the kind of assistance required. 4. Any other information which might facilitate the rescue.
	*NOTE: As a general rule, a ship signals its position in latitude and longitude using degrees and minutes suffixed by north, south, east, or west. In CW, the signal $\overline{\text{AAA}}$ is used to separate the degrees from the minutes. If possible, the true bearing and the distance (in nautical miles) from a known geographic point should be given.	
Direct[illegible] Finding Transmission	A transmission sent immediately after the DISTRESS MESSAGE. This permits DF (direction-finding) stations to fix the position. This transmission will be repeated as frequently as required. In radiotelephone procedure the DF transmission is made only on request.	CW: Two dashes of approximately 10 seconds each followed by the stations call sign. Voice: Suitable signals as requested followed by the station's call sign or other identification.

Figure 16-2.—Components of Distress Traffic.

Acknowledging Receipt of a Distress Message	
CW	VOICE
1. Call sign of the station sending the distress message sent three times.	1. Call sign or other identification of the station sending the distress message spoken three times.
2. Prosign DE.	2. Proword THIS IS (or DE spoken as DELTA ECHO in case of language difficulty).
3. Call sign of the station acknowledging receipt sent three times.	3. Call sign or other identification of the station acknowledging receipt spoken three times.
4. Group RRR.	4. The proword RECEIVED (or RRR spoken as ROMEO ROMEO ROMEO in case of language difficulty).
5. Distress signal SOS.	5. Distress signal.
6. Prosign AR.	6. Proword OUT.

Figure 16-3.—Acknowledging Receipt of a Distress Message.

resume. If, for some reason, control of the distress traffic has been delegated to a station other than the station in distress, the unit in distress should notify the controlling station when silence is no longer needed. The station in control of the traffic should then notify all other stations that normal traffic may be resumed. The message format for cessation of distress traffic is shown in figure 16-4.

URGENCY SIGNAL

The urgency signal is used as an indication that the transmitting station has a very urgent message to transmit concerning the safety of a ship, aircraft, or personnel. With the exception of actual distress signals, the urgency signal has priority over all other communications. All stations that hear an urgency signal must not interfere with the transmission of the message that will normally follow.

The urgency signal can be transmitted only on the authority of the person in command of the ship, aircraft, or other unit that is in danger. The signal can be sent to all stations or to a specific unit. As a general rule, the message following an urgency signal is in plain language. The CW urgency signal is composed of the group XXX sent three times before the call. The voice equivalent for the urgency signal is the word "PAN" sent three times before the call.

URGENCY SIGNAL PROCEDURES

A mobile station on hearing the urgency signal must continue to listen on the same frequency for at least 3 minutes. If nothing further is heard during this period, a shore station should be contacted and advised of the receipt of an urgency signal. After this notification, normal communications may be resumed on other frequencies.

When an urgency signal has been sent prior to a message addressed "To All Stations" (CQ) calling for action to be taken by the receiving stations, a cancellation message must be sent to all stations when the required action has been taken.

SAFETY SIGNAL

A safety signal is sent as notification that the transmitting station is about to send a

Message Format for Cessation of Distress Traffic	
CW	VOICE
1. DISTRESS SIGNAL SOS.	1. The word "MAYDAY"
2. Call CQ ("to all stations") three times.	2. The call "HELLO ALL STATIONS" or CQ (spoken as CHARLIE QUEBEC) spoken 3 times.
3. Prosign DE.	3. The proword "THIS IS" (or DE spoken as DELTA ECHO in case of language difficulties).
4. Call sign of the station sending the message (sent once).	4. Identification of the station transmitting the message (sent once).
5. Time of handing-in of the message.	5. The time of handing-in of the message.
6. Identification and call sign of the mobile station which was in distress.	6. The identification of the mobile station which was in distress.
7. Operating signal QUM ("Normal working may be resumed").	7. The words "DISTRESS TRAFFIC ENDED" (In the maritime mobile service use the words "SEELONCE FEENEE" ("SILENCE ENDED") instead).
8. Prosign AR.	8. The proword OUT.

Figure 16-4.—Message Format for Cessation of Distress Traffic.

message concerning the safety of navigation or providing important meteorological warnings. If operators hear a safety signal, they must continue to listen on that frequency until they are sure that the information is of no interest to them. They must also refrain from any transmissions that may interfere with the safety signal.

The CW safety signal consists of the group TTT sent three times before the call. The voice safety signal is the word SECURITE (say-cur-i-tay) sent three times before the call.

MERCHANT SHIP DISTRESS

Merchant ships use SOS procedures in distress messages to summon assistance during normal marine disasters such as fire, collision, or storm but not as a warning of enemy action.

In wartime, five signals are used by merchant ships to indicate distress due to enemy action. The distress signals are shown in the following list:

Class of Distress	Distress Signal	When Used
Warship raider	WWWW	On sighting or when attacked by enemy warship.
Armed merchant ship raids	QQQQ	On sighting or when attacked by armed merchant ship raider.
Submarine	SSSS	On sighting or when attacked by enemy submarine.
Aircraft	AAAA	On sighting or when attacked by enemy aircraft.
Mine	MMMM	On striking a mine.

DISTRESS WATCHES ASHORE

A NAVCOMMSTA is known to be "open to public correspondence" when it is authorized to operate ship-to-shore circuits to handle commercial message traffic with merchant ships. These NAVCOMMSTAs must maintain (as a minimum) a continuous receiver watch on 500 kHz, being particularly alert during the silent periods.

All naval air activities that have a VHF/UHF tower communications capability must guard 121.5 MHz and 243.0 MHz.

CHAPTER 17

COMMERCIAL TRAFFIC

Naval communications does not compete with privately owned and operated commercial communications companies. By terms of the Communication Act of 1934, however, the Navy is authorized to use its radio stations for reception and transmission of press messages and private commercial messages between ships, between ship and shore, and between shore stations and privately operated ships whenever privately owned stations are incapable of meeting communications requirements.

Instructions contained in NTP 9 cover the handling by U.S. naval communications of all commercial communications, including official government traffic involving tolls, and unofficial traffic involving or not involving tolls. These instructions are based upon the International Telecommunications Convention, Geneva, 1959 and the Telegraph Regulations, Geneva, 1958. The Communication Act of 1934, the Western Union rate and rule books, rules and regulations of the Federal Communications Commission, and applicable Department of Defense (DOD) publications and instructions are other basic documents used in preparing NTP 9.

The policy of the Department of the Navy in the handling of commercial traffic is that:

> "Every effort will be made to provide timely delivery of commercial traffic on an 'as soon as practicable' basis. However, it shall not take precedence over official Government traffic. Neither will guaranteed delivery nor specific delivery times be assured or implied."

The above statement should be brought to the attention of all senders prior to the acceptance of commercial traffic.

COMMERCIAL TRAFFIC CLERK

Each Navy ship, station, or activity authorized to handle commercial traffic or to receive personal messages for transmission via naval communications should designate a commercial traffic clerk. The commercial traffic clerk is designated in writing by the commanding officer. Usually, the commercial traffic clerk is an experienced Radioman but is not necessarily the senior Radioman aboard.

The commercial traffic clerk handles all the commercial traffic funds and prepares all reports concerning the traffic. He is not required to be bonded unless it is required by the Commander, Naval Telecommunications Command. A short summary of duties performed by the commercial traffic clerk follows:

1. To maintain a complete file of all commercial messages accepted for transmission.

2. To keep a complete file of all incoming commercial messages and all official Government messages, received from sources other than naval communications, for abstracting purposes.

3. To maintain and understand all instructions and materials concerned with handling commercial traffic, including rate sheets, bulletins, publications, and forms.

4. To collect proper charges and safeguard funds collected and in his custody.

5. To prepare prescribed reports correctly and on time, forwarding them to the communication officer for review.

The duties of the commercial traffic clerk are performed under the supervision of the communication officer. The communication officer reviews all reports and correspondence prepared by the commercial traffic clerk, forwarding them to the commanding officer for signature.

COMMERCIAL TRAFFIC FUNDS

Naval commercial traffic funds should be kept separate from all other funds. The records of these funds should be inspected monthly, and upon relief of the commercial traffic clerk, by a board consisting of two officers or senior enlisted personnel. One of the inspecting personnel should be from the supply department, if the personnel are available. This inspection should include an audit of all accounts and a verification of the cash balance and rates used. If there is an irregularity in the accounts, the report of the inspection should be forwarded to the Commanding Officer, Navy Regional Finance Center, Washington, DC, via official channels. The report should include endorsements showing what action has been taken or recommendations, if any.

Reports showing no irregularities are retained for at least one year. The original copies of records may be called for by COMNAVTELCOM or Commanding Officer, U.S. Navy Regional Finance Center.

The commandant of a naval district or the commanding officer of a ship, station, or activity establishes the maximum amount of naval commercial traffic funds permitted to accumulate in the possession of the commercial traffic clerk. Unless approved by COMNAVTELCOM, however, this sum may not exceed $100. Accumulated funds must be depositied at least weekly with the supply officer or the disbursing officer. Only such amount is retained as is needed to make change.

When required for remittance, funds so deposited must be made available to the commercial traffic clerk by U.S. Treasury check, payable to the order of the Navy Regional Finance Center, Code FR-FC, Washington, DC, 20371 or Western Union Telegraph Company, as appropriate. As explained in more detail later, checks for Class D messages and Class D messages entitled to Class E privilege are made payable to the Navy Regional Finance Center. Checks for Class E messages are made payable to Western Union.

If the commercial traffic clerk is relieved and no replacement is immediately nominated, the commercial traffic funds should be retained in the custody of the supply officer or the disbursing officer of the command. The communications officer or a naval postal clerk should not handle naval commercial traffic funds.

USES OF COMMERCIAL TRAFFIC FUNDS

Expenditures from naval commercial traffic funds for the following purposes are authorized:

1. Money order fees
2. Postage for mailing reports (if necessary).
3. Registration fees where the commanding officer has determined that registered mail is necessary to protect the reports.

These uses for commercial traffic funds should be documented on the "Statement of Account" (NAVCOMPT Form 2065), which will be discussed later in this chapter.

REFUNDS

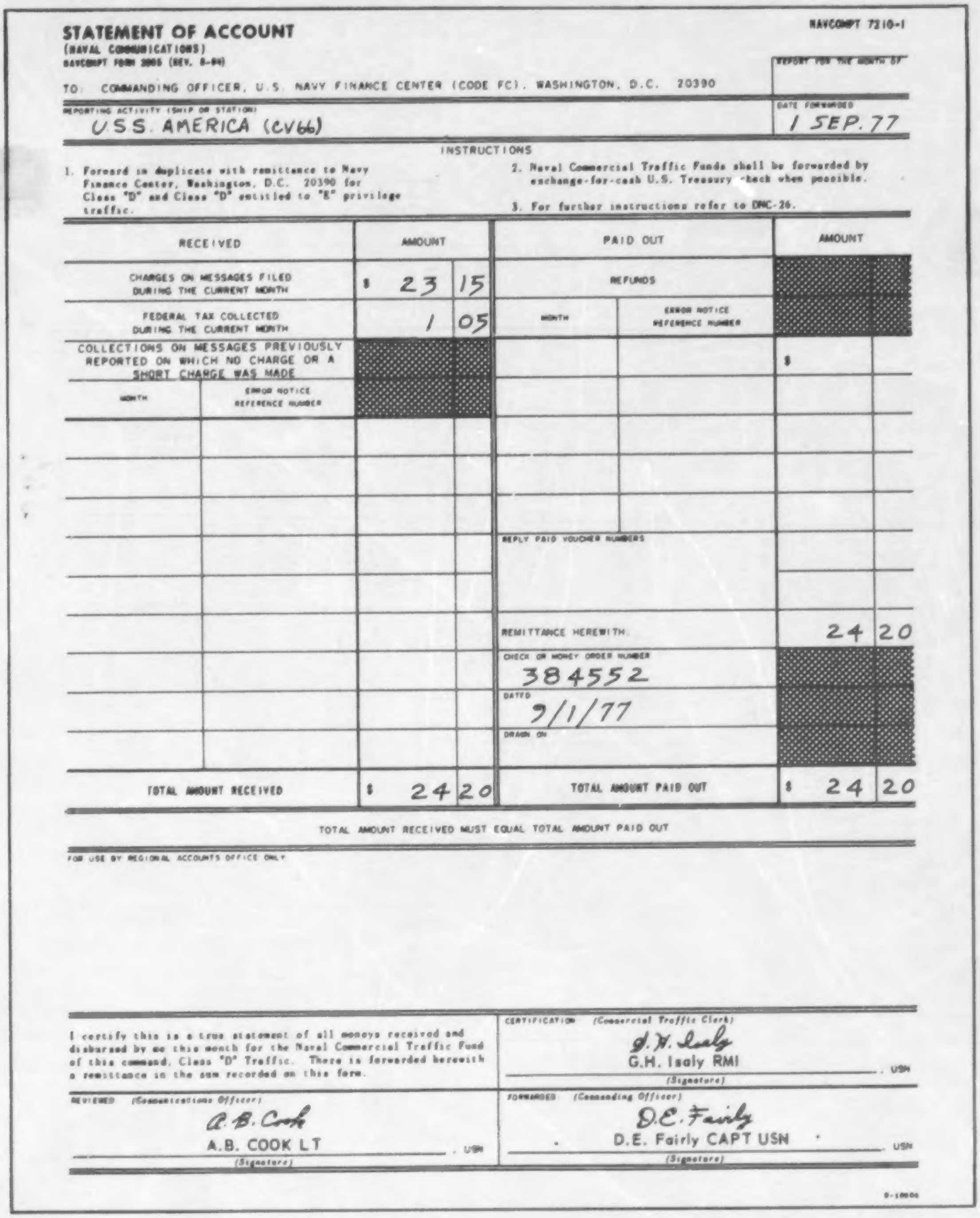
A refund may be made to the person sending a non-Government message when the ship, station, or activity sending the message is unable to get the message through to its destination for reasons such as circuit breakdown, cable break, landline down, or ship out of range. A refund is not due on a message not delivered because of reasons such as "addressee deceased", "addressee unknown", "addressee has moved", or similar causes. Under these conditions the carrier's obligation is considered to be fulfilled.

Copies of messages involving a refund should be sent to the Navy Regional Finance Center, Washington, DC, with an explanation on the message form showing the reason for the refund.

COMMERCIAL TRAFFIC REPORTS

Three abstracting forms are utilized in reporting commercial traffic. Each one is illustrated here and discussed more completely later in this chapter. The following are the form numbers, their titles, and a brief description of the classes of traffic reported on each form:

1. NAVCOMPT 2065, Statement of Account (fig. 17-1): This form is required when remittances are forwarded for Class D private commercial messages, press messages, radiophotos, and Class D messages entitled to Class E privilege.
2. NAVCOMPT 2067, Abstract of Class E Messages (fig. 17-2): This form is used by ships and shore stations originating Class E messages



STATEMENT OF ACCOUNT
(NAVAL COMMUNICATIONS)
NAVCOMPT FORM 2065 (REV. 8-64)

NAVCOMPT 7210-1

TO: COMMANDING OFFICER, U.S. NAVY FINANCE CENTER (CODE FC), WASHINGTON, D.C. 20390

REPORT FOR THE MONTH OF

REPORTING ACTIVITY (SHIP OR STATION) U.S.S. AMERICA (CV66)

DATE FORWARDED 1 SEP. 77

INSTRUCTIONS

1. Forward in duplicate with remittance to Navy Finance Center, Washington, D.C. 20390 for Class "D" and Class "D" entitled to "E" privilege traffic.
2. Naval Commercial Traffic Funds shall be forwarded by exchange-for-cash U.S. Treasury check when possible.
3. For further instructions refer to DNC-26.

RECEIVED	AMOUNT		PAID OUT	AMOUNT	
CHARGES ON MESSAGES FILED DURING THE CURRENT MONTH	$ 23	15	REFUNDS		
FEDERAL TAX COLLECTED DURING THE CURRENT MONTH	1	05	MONTH / ERROR NOTICE REFERENCE NUMBER		
COLLECTIONS ON MESSAGES PREVIOUSLY REPORTED ON WHICH NO CHARGE OR A SHORT CHARGE WAS MADE				$	
MONTH / ERROR NOTICE REFERENCE NUMBER					
			REPLY PAID VOUCHER NUMBERS		
			REMITTANCE HEREWITH	24	20
			CHECK OR MONEY ORDER NUMBER 384552		
			DATED 9/1/77		
			DRAWN ON		
TOTAL AMOUNT RECEIVED	$ 24	20	TOTAL AMOUNT PAID OUT	$ 24	20

TOTAL AMOUNT RECEIVED MUST EQUAL TOTAL AMOUNT PAID OUT

FOR USE BY REGIONAL ACCOUNTS OFFICE ONLY

I certify this is a true statement of all moneys received and disbursed by me this month for the Naval Commercial Traffic Fund of this command, Class "D" Traffic. There is forwarded herewith a remittance in the sum recorded on this form.

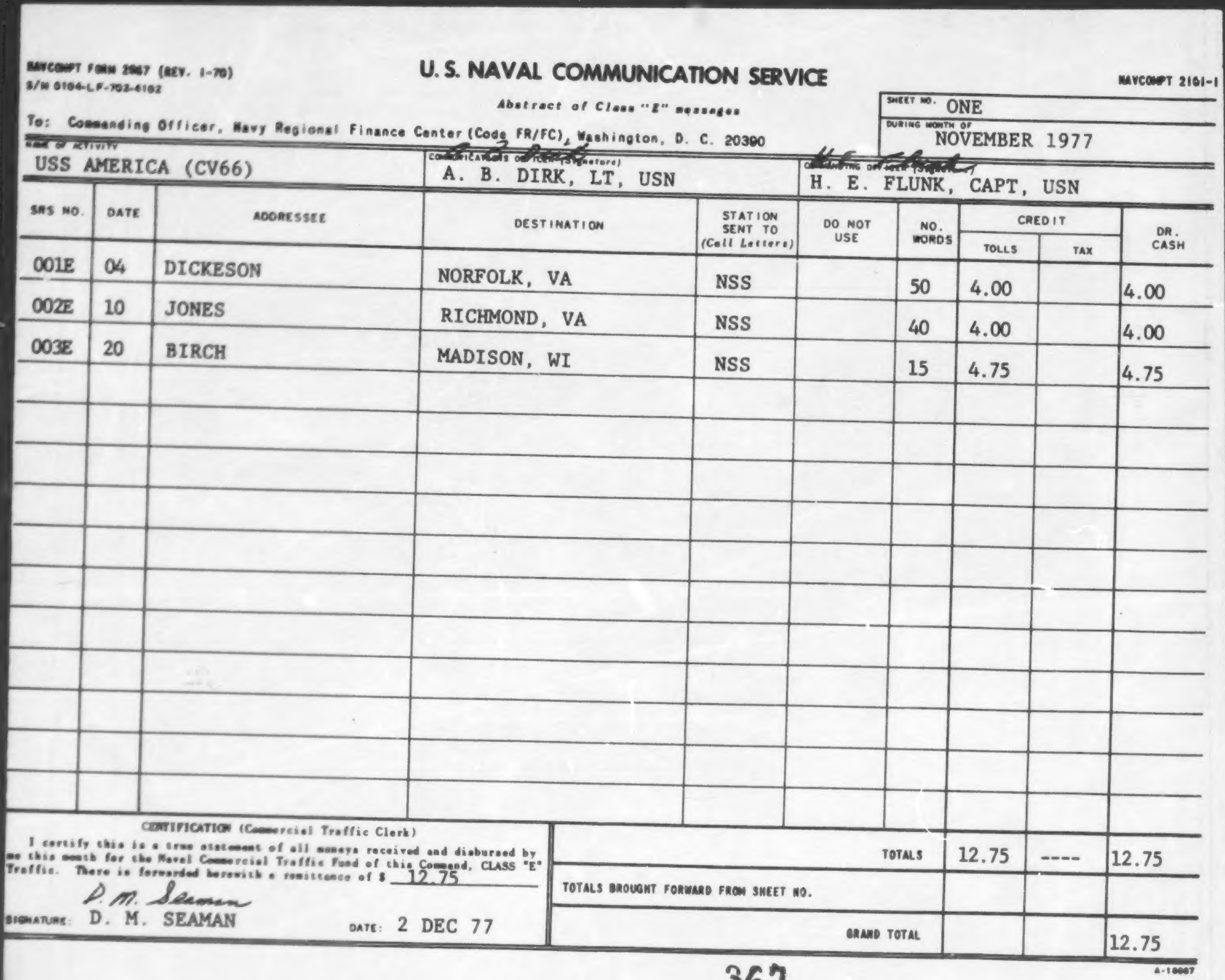
CERTIFICATION (Commercial Traffic Clerk)
G.H. Isaly
G.H. Isaly RMI, USN
(Signature)

REVIEWED (Communications Officer)
A.B. Cook
A.B. COOK LT, USN
(Signature)

FORWARDED (Commanding Officer)
D.E. Fairly
D.E. Fairly CAPT USN, USN
(Signature)

50.18

Figure 17-1.—Statement of Account, NAVCOMPT Form 2065.



NAVCOMPT FORM 2067 (REV. 1-70)
S/N 0104-LF-702-0102

U. S. NAVAL COMMUNICATION SERVICE

NAVCOMPT 2101-1

Abstract of Class "E" messages

To: Commanding Officer, Navy Regional Finance Center (Code FR/FC), Washington, D. C. 20390

SHEET NO. ONE

DURING MONTH OF NOVEMBER 1977

NAME OF ACTIVITY: USS AMERICA (CV66)

COMMUNICATIONS OFFICER (Signature): A. B. DIRK, LT, USN

COMMANDING OFFICER (Signature): H. E. FLUNK, CAPT, USN

SRS NO.	DATE	ADDRESSEE	DESTINATION	STATION SENT TO (Call Letters)	DO NOT USE	NO. WORDS	CREDIT		DR. CASH
							TOLLS	TAX	
001E	04	DICKESON	NORFOLK, VA	NSS		50	4.00		4.00
002E	10	JONES	RICHMOND, VA	NSS		40	4.00		4.00
003E	20	BIRCH	MADISON, WI	NSS		15	4.75		4.75
TOTALS							12.75	----	12.75
TOTALS BROUGHT FORWARD FROM SHEET NO.									
GRAND TOTAL									12.75

CERTIFICATION (Commercial Traffic Clerk)

I certify this is a true statement of all moneys received and disbursed by me this month for the Naval Commercial Traffic Fund of this Command, CLASS "E" Traffic. There is forwarded herewith a remittance of $ 12.75

D. M. Seaman

SIGNATURE: D. M. SEAMAN

DATE: 2 DEC 77

A-10007

Figure 17-2.—Class E Message Abstract, NAVCOMPT Form 2067.

50.20

involving tolls and Class D messages entitled to Class E privilege.

3. NAVCOMPT 2132, U.S. Naval Communication Service Abstract (fig. 17-3): This form is used for:

a. All Class D messages originated by a naval ship.

b. All Class D messages received and delivered on board or relayed by a naval ship.

c. All Class D messages originated, received, forwarded, or delivered by a naval station or activity.

d. All Class A and B messages (including official radiotelephone messages) transmitted by a naval ship directly to a domestic or foreign commercial shore radio station.

e. All Class A and B messages received by a naval ship directly from a commercial shore radio station.

The above mentioned forms are available as cognizant symbol "I" material from the Naval Supply Centers in Norfolk and Oakland.

Copies of the commercial traffic reports, as submitted, should be retained in the ship or station file at least 12 months.

RESPONSIBILITY FOR REPORTS

Commercial traffic reports are required whenever commercial messages involving tolls are handled by a ship or station during any calendar month. The reports are prepared by the commercial traffic clerk and signed by the communications officer and the commanding officer. In the case of submarines (except when on detached duty), the reports are submitted by the tender or submarine base to which the submarine is attached. In the case of service craft attached to a naval district, the reports are submitted by the district commandant. Reports submitted for submarines and service craft in accordance with the above are arranged and labeled for each submarine or service craft originating the traffic.

Monthly commercial traffic reports should be mailed under one cover to the Commanding Officer, Navy Regional Finance Center, Code FR-FC, Washington, DC, 20371. Reports from naval ships should be mailed by the 5th of the month following handling and from naval stations and activities by the 10th of the month. Reports of Class D messages and Class D messages entitled to Class E privilege should consist of an abstract form, one copy of each message reported, a remittance, and a Statement of Account. Class E messages involving toll should be reported with the use of an abstract form, one copy of each message, and the remittance.

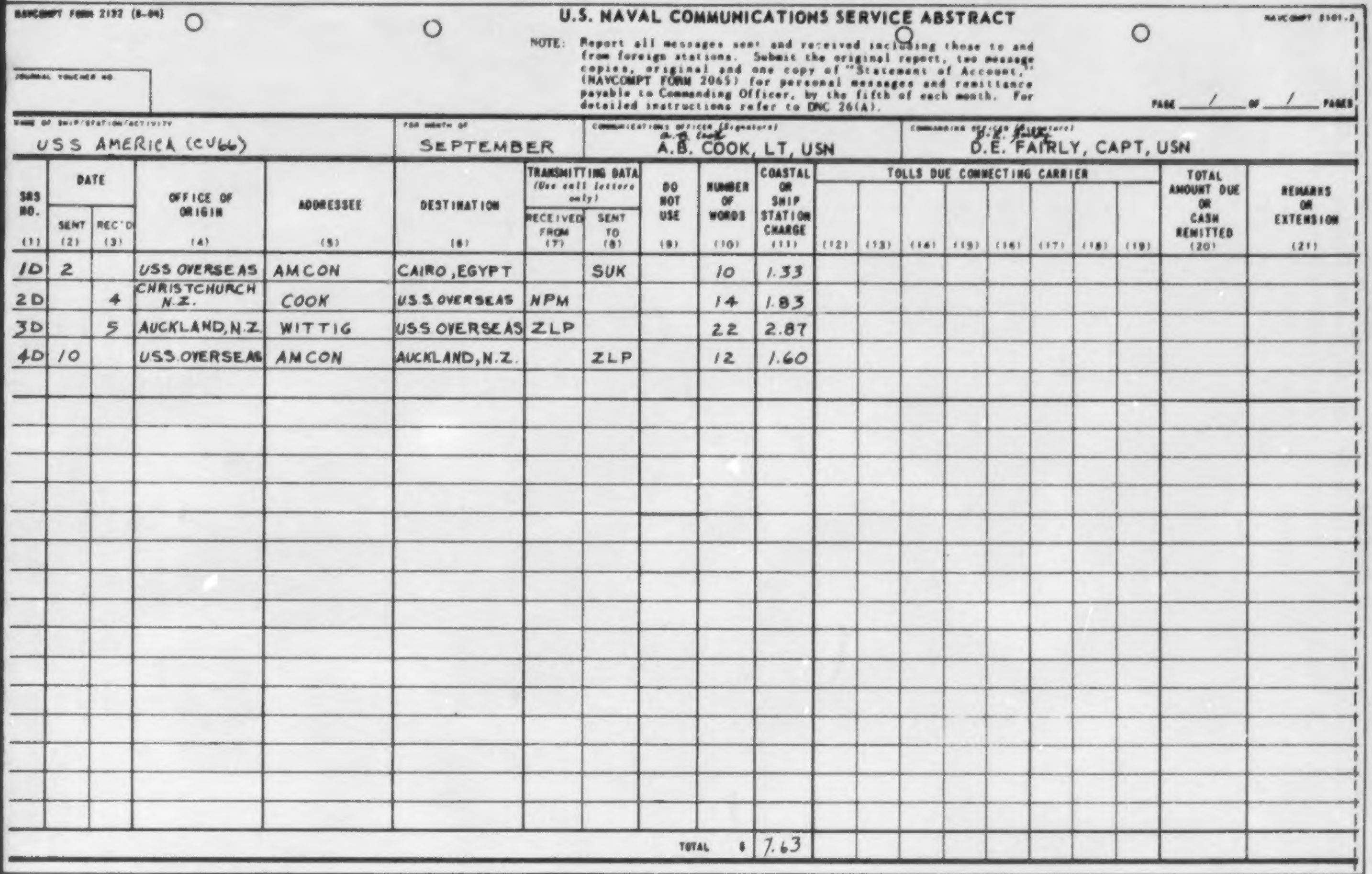
Negative commercial traffic reports are not required when Class D and Class E traffic has not been handled during the calendar month. However, the following statement should be inserted on the first line of the next Class D or Class E abstract submitted: "No Class D (or E as appropriate) traffic handled during the month(s) of ____________________."

SERIAL NUMBERS

All commercial traffic handled by naval communications is assigned serial numbers for accounting and identification purposes. These numbers are known as SRS numbers. Every commercial message handled is assigned an SRS number by each ship, station, or activity involved in the handling.

Naval communications stations assign SRS numbers consecutively up to 10,000. All other Navy activities and ships assign SRS numbers consecutively up to 1,000 on an annual basis, commencing with number 1 on 1 January of each year. When service messages are sent on a commercial message, such service messages are given the SRS number of the message to which they refer, followed by "A" for the first service message, "B" for the second service, and so on. Paid service messages are not affected by this provision. The following capital letters are suffixed to the regularly assigned SRS numbers depending on the class of commercial traffic being reported:

Class of Traffic	Suffix Letter	Example
"A"	A	SRS 1A
"B"	B	SRS 2B
"D" (radiogram)	D	SRS 3D
"D" (press)	P	SRS 4P
"D" (radiophoto)	R	SRS 5R
"D" (entitled to the Class E privilege)	C	SRS 6C
"E"	E	SRS 7E
Service message		SRS 7EA



NAVCOMPT FORM 2132 (8-60)

NAVCOMPT 2101.2

U.S. NAVAL COMMUNICATIONS SERVICE ABSTRACT

NOTE: Report all messages sent and received including those to and from foreign stations. Submit the original report, two message copies, original and one copy of "Statement of Account," (NAVCOMPT FORM 2065) for personal messages and remittance payable to Commanding Officer, by the fifth of each month. For detailed instructions refer to DNC 26(A).

JOURNAL VOUCHER NO.

PAGE 1 OF 1 PAGES

NAME OF SHIP/STATION/ACTIVITY: USS AMERICA (CV66)

FOR MONTH OF: SEPTEMBER

COMMUNICATIONS OFFICER (Signature): A.B. COOK, LT, USN

COMMANDING OFFICER (Signature): D.E. FAIRLY, CAPT, USN

SRS NO. (1)	DATE SENT (2)	DATE REC'D (3)	OFFICE OF ORIGIN (4)	ADDRESSEE (5)	DESTINATION (6)	TRANSMITTING DATA (Use call letters only) RECEIVED FROM (7)	TRANSMITTING DATA SENT TO (8)	DO NOT USE (9)	NUMBER OF WORDS (10)	COASTAL OR SHIP STATION CHARGE (11)	TOLLS DUE CONNECTING CARRIER (12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	TOTAL AMOUNT DUE OR CASH REMITTED (20)	REMARKS OR EXTENSION (21)
1D	2		USS OVERSEAS	AMCON	CAIRO, EGYPT		SUK		10	1.33										
2D		4	CHRISTCHURCH N.Z.	COOK	U.S.S. OVERSEAS	NPM			14	1.83										
3D		5	AUCKLAND, N.Z.	WITTIG	USS OVERSEAS	ZLP			22	2.87										
4D	10		USS OVERSEAS	AMCON	AUCKLAND, N.Z.		ZLP		12	1.60										
								TOTAL	$	7.63										

50.134

Figure 17-3. — U.S. Naval Communication Service Abstract, NAVCOMPT Form 2132.

As is apparent from the above instructions, one message may bear different SRS numbers at the various stations handling it.

REPORT SYMBOLS

The Comptroller of the Navy has assigned NAVCOMPT report symbols to commercial communications reports to aid in handling, auditing, and accounting for these reports. Report symbols consist of the word NAVCOMPT followed by a number. For example, NAVCOMPT 7210-1 is the Statement of Account report. Other report symbols are given in separate discussions of each message class. The appropriate report symbol must be placed on the envelope or cover when commercial traffic reports are forwarded. It should also appear on the abstract form itself. More than one report symbol may be used on one abstract form.

WORD COUNT SYSTEMS

As a means of collecting fees for expense incurred when commercial communications are handled, the Navy uses two systems of word count. Domestic word count applies to domestic messages and is based on domestic rules and regulations. International word count is used for radiotelegrams and international telegrams and is based on international rules and regulations.

Domestic telegrams are messages originated at and addressed to points on shore within the continental United States, Canada, Mexico, Alaska, or Saint Pierre-Miquelon Islands, and transmitted in domestic form by wire or radio over all or part of its route.

A radiotelegram is a message originating in or intended for a mobile station and transmitted over all or part of its route by radio communication channels of the mobile service. International telegrams are messages originating at or destined to points outside the continental United States, Canada, Mexico, Alaska, or Saint Pierre-Miquelon Islands. Both radiotelegrams and international telegrams are drafted in international form.

A detailed explanation of both word count systems is given in NTP 9; hence, it is not repeated here. Many examples in NTP 9 illustrate the rules effectively, showing how representative words and groups are counted differently according to their location in a message address, text, or signature.

COMMERCIAL ABSTRACTING

This section is devoted to a more detailed discussion of message classes and methods of abstracting commercial messages.

Of the five classes of messages, Class C messages are not involved in commercial abstracting; therefore, they are not discussed here.

CLASS A AND CLASS B MESSAGES

Class A and Class B messages are official U.S. Government messages. Class A messages consist of official messages of the Department of Defense. Class B comprises official messages of U.S. Government departments and agencies except for Department of Defense messages. Both classes are treated together in this section because of the similarities in handling, abstracting, and accounting.

Both Class A and Class B messages are prepared in joint form for transmission over military circuits. Detailed coverage of procedures for handling messages over military circuits is provided in NTP 4.

Class B messages requiring commercial refile must always carry an accounting symbol to denote the Government department or agency responsible for payment of commercial charges. When the message is filed with a domestic communication company, the accounting symbol is preceded by the Government indicator GOVT. This indicator appears as the first word in the address. In messages sent to or via foreign communication companies, the Government indicator is changed to US GOVT.

Handling Over Commercial Communication Systems

When it is necessary to file or refile a Class A or Class B message with a commercial communication company, the following rules apply:

1. When filed directly with a commercial communication company by an originator outside the continental United States or destined to an addressee outside the U.S., messages are sent via the nearest U.S. military communication facility serving the area in which they originated.
2. Provided either originator or addressee is not served by military communications, messages may be filed directly or refiled with Western Union without further transmission on military circuits. This rule applies when charges for

delivery to an addressee are the same as (or less than) such charges for delivery from a designated commercial refile point.

3. When a message is refiled by a shore station within the continental U.S. and addressed to a point in the United States, Canada, Mexico, Alaska, or Saint Pierre-Miquelon Islands, domestic form with domestic word count is used. The point of actual origin is added to the signature.

4. When a message is refiled by a shore station in the continental U.S. and addressed to points outside the United States, Alaska, Canada, or Mexico, or Saint Pierre-Miquelon Islands, international form and word count are used. The point of refile is treated as the point of origin; point of actual origin is added to the signature.

5. When a message is filed or refiled by a shore station outside the continental U.S., international form and word count are used. The point of file serves as the point of origin, or the point of refile is the point of origin, and the point of actual origin is added to the signature.

6. When a message in joint form must be sent through a commercial communication system for further transmission by a military system, the message in joint form—complete with heading—is embodied in the text of the commercial message.

7. When a message is transmitted directly by a Navy ship to a commercial shore radio station, international form and word count are used.

The following is an example of the form for a GOVT NAVY message as transmitted by a ship to a shore station for refile with a commercial company:

```
RTTUZYUW RULYEDO1470 2921400-UUUU--
    RUWDSAA.
ZNR UUUUU
R 191400Z OCT 77
FM USS AUSTIN
TO JOHN N DOE
          FOUR TWO TWO QUEENS COURT
          ERIE PA
BT
UNCLAS
YOUR LEAVE EXPIRES ON BOARD AT NOR-
    FOLK VA
0730 25 OCT 77
BT
#1470
```

The preceding message would be commercially refiled in the following form (underlined words chargeable):

```
CK 12 WASHINGTON DC 19 OCTOBER 1977
    424PME
GOVT NAVY
JOHN N DOE
FOUR TWO TWO QUEENS COURT
ERIE PA
YOUR LEAVE EXPIRES ON BOARD AT NOR-
    FOLK VA 0730 25 OCT 77
                COMMANDING OFFICER
                USS AUSTIN
```

Abstracting Class A and B Messages

Class A, B and official radiotelephone messages transmitted directly to a commercial shore radio station by a Navy ship must be reported on NAVCOMPT Form 2132. (See fig. 17-3.) This monthly report, symbol NAVCOMPT 2102.2, must be forwarded to the Navy Regional Finance Center, Washington, DC 20371. Two copies of all messages are required with each report. No remittance is made; settlement of accounts is the responsibility of COMNAVTELCOM. Reports from ships must be mailed by the 5th of the month after handling.

Incoming Class A and B messages received by Navy ships directly from commercial shore radio stations are reported on NAVCOMPT Form 2132. Other requirements are the same as for outgoing messages explained earlier.

Naval shore stations designated commercial refile activities in ACP 117, U.S. Supp-1 are required to submit monthly reports of all Class B messages refiled with commercial communication companies. A speedletter report is made, but it does not utilize any of the NAVCOMPT forms mentioned previously.

Reports are mailed directly to the Commander, Naval Telecommunications Command within 10 days after receipt and verification of the traffic billing of the commercial communication company. A speedletter report must contain the following information in the order indicated:

1. Report of Class B messages.
2. Calendar month and year of the report.
3. Inclusive Class B message serial numbers reported.

The speedletter report must be accompanied by two copies of each message reported.

One copy must be in the military form in which received, arranged in SRS number order, on metal file fasteners, between cardboard covers, and in groups of 100 or fewer messages. These covers must be labeled to indicate the type of traffic, the name of reporting station, and the month and year of commercial refile.

The second copy of each message must be in the commercial form in which it was refiled, segregated into packets according to accounting symbols.

Both message copies must bear complete transmission data and include the following information in the lower right corner:

1. SRS number (e.g., SRS 23B).
2. Accounting symbol (e.g., INT).
3. Commercial company and city where refiled (as Western Union, WASHDC).
4. Commercial service indicator (e.g., NL).
5. Commercial charges (e.g., $1.25).
6. Date and time of refile (as 011300Z AUG 77).

Copies of service messages relating to commercially refiled Class A and B messages must be forwarded with copies of the messages to which they pertain.

Responsibility for Payment

A reporting activity does not collect toll charges or send remittances when it forwards Class A and B message reports. In brief, payment for Class A and B messages refiled with commercial communication companies is effected according to the ensuing explanation. For Class A and B messages transmitted by Navy ships to commercial shore stations, CNO is responsible for the settlement of accounts. Because bills submitted by commercial companies often contain amounts for other classes of messages, however, initial payment is made by NAVREGFINCEN, Washington.

Charges for Class B traffic are then billed to COMNAVTELCOM by NAVREGFINCEN, Washington. In turn, COMNAVTELCOM bills other Government agencies responsible for originating their Class A and B messages involving toll charges. Thus, naval communications is reimbursed for the non-Navy messages handled.

Payment is handled differently for Class A and B messages refiled with commercial companies by shore stations. Commercial communication companies bill a refile activity directly. The refile station verifies the monthly billing, certifies it as official U.S. Government traffic, and forwards the certified billing (with supporting message copies), for payment, to the local disbursing office of the NAVFINCEN serving the area in which the refiling activity is located.

CLASS D MESSAGES

Class D messages are non-Government (private-commercial) messages handled by naval communications that were received or sent via commercial communication companies. Class D messages include—

1. Commercial (private) messages
2. Commercial (private) messages entitled to Class E privilege.
3. Press and related service messages.
4. Radiophotos/Facsimile.

Class D messages are always in commercial form. Handling of Class D traffic by Navy ships and stations usually is suspended or curtailed in wartime.

Class D messages are not accepted, transmitted, or relayed by military communications when or where it is possible for the messages to be handled by commercial means, unless specific exceptions are made.

A Class D message is used when the sender does not qualify for, or the message destination does not meet, the restrictions imposed for Class E messages, e.g., a message from or to an addressee in Manila, Republic of the Philippines, would be a Class D message.

Commercial (Private) Messages

Class D commercial (private) messages may be filed during peacetime by any person, whether in the naval service or not, at any of the following ships, stations, and activities:

1. All naval ships at sea or in a port having no adequate and reliable commercial facilities available.

372

2. All overseas naval stations and activities at locations where adequate and reliable commercial communication facilities are not available.
3. The naval communication stations open to public correspondence and authorized to handle commercial ship-to-shore and shore-to-ship traffic.

In naval ships, the requirements for filing commercial messages are as follows:

1. Approved by the commanding officer, or officer designated by him, and duly released.
2. Filed with the commercial traffic clerk who determines word count and collects the charges.

Following transmission, the original and one copy of the message with proper servicing data entered thereon are returned to the commercial traffic clerk for filing and abstracting purposes.

In the event there is doubt as to the proper charges to be collected and such charges cannot be determined by the appropriate operating signal, the maximum charge is collected and the name and address of the sender entered on the message form in order that proper reimbursement may be made when the account is audited.

International Form

A commercial message originating at or relayed by a naval ship or a NAVCOMMSTA open to commercial traffic is handled in the international form.

In the following example of Class D commercial messages in international form, chargeable words or groups are underscored. An explanation of component parts is given at the conclusion of this message example.

PCH DE NMIB NR1 INTL USS AMERICA/
NMIB CK26
12 1430
$\overline{\text{BT}}$ MP $\overline{\text{BT}}$
LOUIS COLBUS
69 EASTTHIRTYSIXST
NEWYORKCITY
$\overline{\text{BT}}$
SELL TEN SHARES COMPTOMETER AND TWENTY SHARES PULLMAN BUY SIXTY SHARES MAGNAVOX ALL AT MARKET ADVISE TRANSACTION DATE $\overline{\text{BT}}$ FORD COX AR NMIB K

After the call and station serial number in this example appears the international abbreviation INTL. Next is the office of origin, USS AMERICA, followed by her call sign. The check (CK26) consists of the number of chargeable words in the address, text, and signature. (Remember that chargeable words are underscored in this example.) In a commercial message such as this one, the date and local time of filing are always given in two numeral groups, with the date separated by a space from the four-digit hours and minutes group.

The message address contains the paid service indicator MP in addition to the name and address of the addressee. This particular paid service indicator (MP) means that the sender requests delivery of his message to the addressee in person—not by mail or telephone. More than a dozen different service indicators are authorized; NTP 9 carries the complete list. As shown in this message example, the paid service indicator is the first word of the address; it is counted as a chargeable word and is included in the CK.

After the text is the sender's name, called the signature. Although it is not obligatory to transmit the signature, when transmitted it is chargeable and is separated from the text by the prosign $\overline{\text{BT}}$. The prosign $\overline{\text{BT}}$ in this message appears several times. This prosign separates the preamble from the paid service indicator, paid service indicator from the rest of address, address from text, and text from signature. Prosign $\overline{\text{BT}}$ is never counted or charged in the CK.

Domestic Form

The following is an example of the domestic form of Class D message, with the chargeable words or groups underscored:

NR1 CK11 NL NAVSTA ADAK 16 AUG 77
1030 AMP
RABER KIEF, INC.
SEATTLE WASHINGTON

THIS COMMAND WILL NEED YOUR ASSISTANCE IN OBTAINING SUPPLIES PREVIOUSLY DISCUSSED. H. FLICK

The example above reflects that a single address and signature are not charged for in a domestic telegram. Therefore, the check (CK) will consist of the total number of words in the text plus any extra matter that may be added in the address or signature. The service indicator provides supplementary instructions requested by the originator, such as DL (day letter) or NL (night letter), etc. The commercial communications companies show the city or town where the message was filed (originated). The domestic form has the month and year transmitted in addition to the date and time. The hour is followed by "AM" or "PM" and the civil zone time indicator (E for Eastern time, P for Pacific time, etc.). The normal address of a domestic telegram is transmitted free of charge. A complete address cannot be over-emphasized. The text of the message and any extra matter added to the address or signature is counted and charged for. One plain language signature is transmitted free. Coded signatures are charged for. An extra passing instruction added to the address would also be charged for.

Charges and Accounting

All messages involving tolls should be prepaid. Charges for messages comprise the following:

1. The charges which accrue to land radio stations.
2. The charges which accrue to the mobile (ship) radio station.
3. The relay charges of the intermediate land or mobile radio station.
4. The charges for service over landlines, cable, and special service required by the sender, if any.

After the rate-per-word for transmission over the entire distance involved has been computed, the charges for the message are determined by multiplying the rate-per-word by the number of chargeable words. Special service charges and taxes, if applicable, are applied and added to determine the total charge.

All charges due on commercial (private) messages should be collected from the sender in advance of the transmission. The specific rates for commercial messages change from time to time and are included in NTP 9.

Rate Requests

The International Telecommunications and Radio Conferences held at Geneva in 1959 authorized shipboard stations to make inquiry without cost to coastal stations concerning proper rates for messages for which they do not have necessary information. Because Navy ships are not issued commercial tariff books used for computing charges for Class D messages, it is necessary to send a rate request (QSJ or service message) to determine charges on each message. Operating signal QSJ (preceded by $\overline{\text{INT}}$ for military usage, or followed by $\overline{\text{IMI}}$ for operations with commercial stations) means "What is the charge to be collected per word to ______________ including your internal telegraph charge?" As a reply QSJ means "The charge to be collected per word to ______________ including my internal telegraph charge is ______________ francs."

Francs should be used to express the charges in international communications. When the request is handled on U.S. military circuits, between NAVSTA GUANTANAMO BAY CUBA and NAVCOMMU WASHINGTON, for example, the total charges in the QSJ answer should be expressed in United States dollars. A copy of the rate request and the reply concerning the charges on all commercial messages should be attached to the applicable commercial message that is submitted to the Navy Regional Finance Center, Washington, DC.

Abstracting
Class D Messages

Class D messages are reported on NAVCOMPT Form 2132. Whenever Class D messages originate in your ship or station, the money paid by senders must be forwarded with the abstract. The Treasury check or money order used for a remittance must be made payable to the Navy Regional Finance Center, Washington DC. Actual transfer of funds between naval communications and commercial communication companies is made by the Navy Regional Finance Center.

A complete Class D message report consists of the following:

1. Abstract (NAVCOMPT Form 2132).
2. Copy of each Class D message.
3. Statement of Account, NAVCOMPT Form 2065 (original and one copy).
4. Remittance.

Special attention is directed to the necessity of reporting all Class D messages handled (whether charges are involved or not), together with any QSJ or service message exchanges. Ships sometimes mistakenly fail to report Class D messages received over Navy circuits. Failure to make these reports often results in financial loss to the Government. Such failure to make the required report of either sent or received messages usually causes needless correspondence and delay in settlement of accounts.

Message copies forwarded with an abstract must be legible and complete, including full transmission or receiving data. Duplicates must be retained in ship or station files for at least 12 months. Message copies forwarded and duplicates retained in files must show any discrepancies in counting chargeable words; an explanation of delays exceeding 1 hour between receipt and transmission in relaying, or between filing time and transmission time; charges collected, if any; and other pertinent information deemed appropriate.

In abstracting Class D messages, the name of the point of origin should be shown on the abstract (Form 2132). In the case of communications with ships (naval or merchant), the call sign is shown on both the abstract and the message copy immediately following the name of the ship. The ship name and call sign are separated by a fraction bar. The report symbol for Class D message reports is NAVCOMPT 2101.2.

Safety of Life Messages

There are several special types of authorized commercial (private) messages listed in Chapter 3 of NTP 9. One of the special types worthy of note here is the "safety of life" message.

Safety of life messages are accorded absolute priority of transmission. Every office receiving a message presented as one relating to the safety of life at sea or in the air should forward it as such. A safety of life message is identified by the indicator "SVH" both at the beginning and at the end of the preamble. Telegraph offices should exercise no control over safety of life messages. They must be transmitted and delivered at once.

Rates

The charges for commercial (private) messages are subject to change as promulgated by message corrections to NTP 9. To compute rates, it is always advisable to consult NTP 9 or obtain the charges via a "QSJ" rate request, if needed. At some commands where a large volume of commercial traffic is handled, it is advisable to make a chart listing the type of message, the number of words chargeable, and the rate to charge the sender. This is used for the convenience of both the commercial traffic clerk and the sender in the interest of saving time. The chart, naturally, must be updated each time the charges are changed in NTP 9. This may happen once a year, at the most.

CLASS D MESSAGES ENTITLED TO CLASS E PRIVILEGE

Occasionally, because of the location of addressees, naval personnel are unable to send a message in Class E form, even though message contents comply in all respects with provisions for Class E messages. In other words, the addressee is at a geographical location other than the continental United States; for example, Hawaii, Puerto Rico, Panama, Japan, or Europe.

A category of message known as "Private commercial message (Class D) entitled to Class E privilege" has been established with the view of making available to such personnel a modified version of Class E message. Particular care must be taken in handling this category of message and accounting for it to ensure that it is not combined and reported with regular Class E traffic.

Class D messages entitled to Class E privilege are handled in international form as shown in the message example at the conclusion of this explanation. For identification purposes, each message carries the symbol COMLE as the first word of the text; COMLE is counted and charged for as one word. Therefore, this type of message is at times referred to as a Class D COMLE. Following is an example of a Class D message entitled to Class E privilege.

```
RTTUZYUW RUHGMIB0410 3002000-UUUU—
   RUHGSUU.
ZNR UUUUU
R 272000Z OCT 77
FM USS AMERICA
TO NAVCOMMSTA HONOLULU HI
BT
UNCLAS //N00000//
USS AMERICA CK18 27 1800 BT LT BT
MRS H. E. FLICK
HOTEL HILTON HONOLULU HI
BT
COMLE MEET ME IN KANUI RESTAURANT
   AT SIX.
HARLEY
BT
#0410
NNNN
```

Charges

The charges for Class D messages entitled to the Class E privilege are collected from the sender in advance of transmission and include commercial shore station receiving charges and tolls involved in the landline or cable transmission to effect final delivery.

In computing the charges, the handling to be performed by naval communications is without charge. The charges collected from the sender are those charges involved in the handling and delivery by a commercial communication company. International word count applies.

When the message is transmitted to a commercial shore radio station, the coast station charge and the internal telegraph charge are collected. When the message is transmitted to a naval station or activity, only the commercial refile charge is collected. In many cases, the correct charges for the handling and delivery by the commercial communication company can be obtained by use of the operating signal QSJ or by service message.

Abstracting

Ships and stations originating Class D messages entitled to Class E privilege are required to submit monthly reports under report symbol NAVCOMPT 2101-1 covering all such messages originated. For this report, NAVCOMPT Form 2067 is used.

Reports of Class D messages entitled to Class E privilege are comprised of the following forms:

1. The abstract, NAVCOMPT Form 2067.
2. One copy of each message, showing complete transmission data. A related rate request (QSJ or service message) must be attached to the message.
3. The statement of account, NAVCOMPT Form 2065, in duplicate.
4. The remittance, made payable to Navy Regional Finance Center, Washington, DC.

An additional monthly report is required of shore stations effecting commercial refile of Class D messages entitled to Class E privilege. For this report, NAVCOMPT Form 2132 is the proper form. If the shore station also handled "regular" Class D traffic during the month, the two reports can be combined.

Commercial traffic clerks must exercise extreme caution to ensure that this category of message is not reported with the regular Class E message (to be discussed later) and that the check or money order (remittance) is not made payable to the Western Union Telegraph Company. As we shall see later in this chapter, the check made out to Western Union is for Class E messages only.

PRESS MESSAGES

In peacetime, the Navy frequently grants permission for duly accredited news reporters to go to sea in Navy ships for the purpose of reporting naval operations and activities. In such cases reporters usually are authorized to file press messages on board. The same privilege may be extended at isolated overseas bases where commercial communication facilities are not available.

When correspondents are embarked, equitable treatment should be extended to all. The command should ensure that the press messages do not overload the facilities available. Consideration must be given to official traffic. Normally, press messages take precedence immediately after operational traffic. As a category, press messages should be handled on a "first-come, first-served" basis.

PRESSE and DPR Indicators

Particular care should be exercised by ships and stations when they use the indicators PRESSE and DPR. The paid service indicator "PRESSE" is used on all press messages either transmitted to or refiled with an international communication carrier by naval communications. The domestic service indicator DPR (day press rate), followed by the word "COLLECT" or "PAID" as appropriate, should be used on press messages transmitted directly to or from a continental United States naval station or activity and handled commercially by the Western Union Telegraph Company only. The indicators PRESSE and DPR cannot be used together in the same message.

Charges for Press Messages

It is preferable that correspondents not pay for press messages when filed, but payment may be accepted if a United States correspondent desires to do so. In the case of payment, the principle of "tolls follow the traffic" is applied and the full charges are collected from the sender. The commercial charges could be ascertained by QSJ or service message. When the correspondent elects not to pay for the press message, settlement should be effected by the Navy Regional Finance Center, Washington, DC, based on the abstracts submitted by the originating or refiling station. In international communications, press messages cannot be sent collect. However, the correspondent should have the charges billed to the newspaper or news association to which he is accredited. A United States correspondent may pay the charges involved in advance of the transmission.

Press messages transmitted by naval ships and naval stations overseas to a continental United States naval station or activity for commercial refile by the Western Union Telegraph Company to a point in the United States may be transmitted "DPR PAID" or "DPR COLLECT," depending on the correspondent's wishes. This would mean the correspondent can pay the charges in advance or have the charges billed to his newspaper or news association. When the charges are to be billed to his newspaper or news association, the amount of the bill prepared by the Navy Regional Finance Center covers Navy handling only; the commercial carriers involved are responsible for the collection of their portion of the tolls. On the other hand, if the charges are paid in advance, the tolls involved in the total transmission are collected from the sender. Subsequently, the Navy Regional Finance Center, Washington, DC will effect settlement with the Western Union Telegraph Company.

The international system of word count is used on all press messages handled by naval communications. The paid service indicator PRESSE, when applicable, is written as the first word of the address and charged for as one word. The indicator DPR, when applicable, is written in two places: first, in the preamble following the CK, and second, in the address as the first word of the address. DPR is not counted or charged for in the preamble, but is counted and charged for as one word in the address.

There is a standard rate for press messages handled by naval communications. As this rate changes from time to time, it is best to consult NTP 9 for the appropriate charges.

Abstracting Press Messages

Ships and stations handling press messages are required to submit monthly reports. Press messages are reported on NAVCOMPT Form 2132.

The SRS serial numbers assigned to press messages use the suffix letter P after the number; for example, SRS 116P. Remember that SRS numbers are used for message identification in abstracting and accounting only. They are never transmitted.

Press message abstracts, accompanied by message copies and remittances, are forwarded to the Navy Regional Finance Center, Washington. Remittances are by Treasury check or money order, made payable to the Navy Regional Finance Center, Washington, DC 20371. Reports from ships are due in the mail by the 5th of the month after handling; from shore stations, by the 10th.

Examples

The following is an example of an international commercial form press message for transmission to any commercial shore station. It must be noted that international commercial form press messages are never sent with a COLLECT indicator.

RTTUZYUW RULYMNO0001 3001200-UUUU—RULYSUU.
ZNR UUUUU
R 271200Z OCT 77
FM USS JOHN PAUL JONES
TO NAVCOMMSTA HONOLULU HI
BT
UNCLAS //NO2373//
INTL USS JOHN PAUL JONES NR1/CK95 16 1430 BT
PAGE 1/50 BT
PRESSE BT
TOKYO DAILY NEWS TOKYO JAPAN BT
(FIRST 46 WORDS OF PRESS TEXT, AND 4 WORDS OF SERVICE INDICATOR AND ADDRESS) BT
NR1 USS JOHN PAUL JONES 1430 PRESS PAGE 2/45 BT
(REMAINING 44 WORDS OF TEXT PLUS ONE WORD OF SIGNATURE) BT TARAWA
BT
#0001
NNNN

The following is an example of a domestic form press message with naval heading for transmission to any Navy shore station in the continental United States for delivery by the Western Union

Telegraph Company to an address in the continental U.S.

RTTUZYUW RULYMNO0001 3001201-UUUU—RULYSUU.
ZNR UUUUU
R 271201Z OCT 77
FM USS JOHN PAUL JONES
TO NAVCOMMSTA NORFOLK VA
BT
UNCLAS
CK 95 DPR COLLECT USS JOHN PAUL JONES 27 OCT 77
115PME VIA WESTERN UNION BT
DPR COLLECT
NEW YORK TIMES
220 SOUTH STREET NEW YORK BT
(PRESS MESSAGE TEXT DIVIDED INTO TRANSMISSION SECTIONS IN ACCORDANCE WITH APPROPRIATE INSTRUCTIONS FOR LONG MESSAGES OF OVER 90 LINES OF TYPEWRITTEN TEXT) BT TARAWA
BT
#0001
NNNN

RADIOPHOTOS

Radiophoto transmission is between Navy facsimile units only. Exceptions to this rule must be authorized by COMNAVTELCOM.

In addition to official Navy pictures and graphic material, including those for general distribution to news associations, Navy radiophoto services may be authorized for transmission of commercial pictures. Commercial pictures are of two classes: (1) those for general distribution to newspapers and news associations, and (2) exclusive commercial pictures filed by correspondents and addressed specifically to newspapers or news associations to which they are accredited.

Exclusive commercial pictures are the only ones for which the Navy charges for handling. Thus, they are the only ones requiring abstracting and accounting.

Exclusive commercial pictures are abstracted in the same manner as press messages. They also are reported on the same NAVCOMPT form. Abstracts forwarded to NAVREGFINCEN, Washington should be mailed by the 5th of the month from ships, by the 10th from shore stations, and must be accompanied by a copy of each exclusive commercial picture transmitted and received.

For exclusive commercial pictures, SRS numbers are followed by the letter R; for example, SRS 24R.

Normally, charges for exclusive commercial picture transmissions are not collected at the time of transmission. Accounting necessary for settlement of Navy charges due is performed by NAVREGFINCEN, Washington. If the sender desires, however, charges may be collected in advance of transmission. In such an instance, the remittance and statement of account are included in the report. The flat rate charge for a 7- by 9-inch glossy picture is $30.00.

CLASS E MESSAGES

Class E messages are personal messages. Part of a Radioman's job is to restrict the routing of such messages to keep them personal. All communications personnel should be instructed that under no circumstances are they allowed to devulge the contents of Class E messages to any unauthorized personnel.

Privileges of Class E messages are restricted to the Naval Establishment. There is not a comparable service available to the Armed Forces as a whole. The Class E privilege exists primarily as a morale factor to afford naval personnel at sea or at overseas duty stations a means of rapid communications for personal matters. All overseas naval stations and activities and all naval ships are authorized to handle Class E messages. Continental United States stations are extended Class E privileges where commercial communications are unavailable. In time of war or emergency, the Class E privilege may be suspended at the discretion of COMNAVTELCOM.

Non-naval personnel aboard naval ships or isolated overseas areas served by naval communications may be extended Class E privilege by the commanding officer when commercial communications facilities are unavailable or inadequate. The personnel afforded the Class E privilege should be in one of the following categories:

1. U.S. military personnel of other services.
2. Members of Congress or other important U.S. Government, state, and municipal officials and their dependents.
3. Dependents of U.S. military personnel.
4. Retired U.S. military personnel and their dependents.
5. Civil Service employees of the U.S. Government.

6. U.S. Navy technicians.
7. U.S. media representatives while embarked in U. S. Navy ships.

Refile of Class E Messages

NAVCOMMSTA Stockton, California and NAVCOMMU Washington, DC are the authorized Navy refile points for Class E messages from and addressed to authorized personnel on board ships and overseas duty stations. There is no charge for processing these messages via the naval communications circuits. Therefore, the only charge incurred by the sender is that amount charged by the commercial carrier for the delivery from the Navy refile point to the addressee. When transmitted over U.S. Navy circuits, Class E messages should not be given a precedence higher than ROUTINE, except in the most unusual circumstances as determined by the commanding officer. Class E messages concerning death or serious illness should be refiled and delivered promptly, ensuring that messages in this category are not unduly delayed.

Non-Toll Class E Messages

There are several instances where a Class E message that does not involve tolls may be transmitted. In general, these are personal messages handled between ships, and from ship to shore, shore to ship, and shore to shore, when both the originator and addressee are outside the continental United States and in the same ocean area. Ocean area, as used here, should be interpreted as follows: naval ships, stations, and activities in the Atlantic, Mediterranean, Caribbean, and Middle East areas are considered to be in the same ocean area. Ships, stations, and activities in the Pacific, Far East, and Alaskan areas are considered to be in the same ocean area.

A toll free Class E message can be sent from a ship or overseas station to a continental U.S. addressee as long as the ship or overseas activity is in direct (point-to-point) communications with the shore station, and the final delivery can be made without the use of commercial communications. As long as a commercial company is not involved in the delivery, there is no charge for the Navy circuit routing.

The following is an example of a non-toll Class E message from a naval ship to a naval activity. This example could also apply to non-toll Class E messages from ship to ship, station to ship, or station to station:

```
RTTUZYUW  RULYMIB0001  3001230-UUUU—
    RULYSUU.
ZNR UUUUU
R 271230Z OCT 77
FM USS AMERICA
TO NAVSTA GUANTANAMO BAY CUBA
BT
UNCLAS //N00000//
MSG RMC LARRY HOLLINGSWORTH
RECEIVED  PICTURES  FROM  LAST  TRIP.
    LYNDA AND CHILDREN APPRECIATE THE
    HELP. SEE YOU SOON.
HARLEY
BT
#0001
NNNN
```

It is also possible to send a collect Class E message to the Navy Federal Credit Union, Washington, DC and the Navy Federal Credit Union, San Diego. The command sending the collect Class E message must be a ship or naval activity overseas, as outlined above. NTP 9 provides examples of collect Class E messages.

Personnel on board ships and overseas activities may also receive telegrams from a person outside the Naval Establishment at no cost to the military person. The originator of such a message usually sends a Western Union telegram to either NAVCOMMU Washington, DC or NAVCOMMSTA Stockton, CA (depending on the location of the addressee) for refile with the correct telegraphic address of the military person. The correct telegraphic address should be comprised of the individual's name and rank or rating, ship or station, in care of the appropriate communication station or communication unit mentioned above. When the message arrives at the refile station, the sender has already paid Western Union for the transmission from the point of origin to the refile station. The refile station then routes the message to the fleet broadcast or overseas circuit, for which there is no charge. No accounting or abstracting is necessary by the commercial traffic clerk because the Navy has handled no money.

Toll Class E Messages

A toll Class E message is one handled partially by a commercial carrier. This type of message is subject to toll because the refile station must transfer the message to Western Union for delivery to the addressee. The two naval communications activities authorized to receive and refile Class E messages commercially with Western Union are NAVCOMMU Washington, DC and NAVCOMMSTA Stockton, CA. If the originator is in the Pacific Ocean, Far East, or Alaska area, Class E messages should be addressed to "NAVCOMMSTA CLASS E REFILE STOCKTON CA" for relay to Western Union. If the originator is in the Atlantic, Mediterranean, Middle East, or Caribbean area, the Class E messages should be sent to "NAVCOMMU CLASS E REFILE WASHINGTON DC."

Class E messages may be sent as "telegrams" or "overnight telegrams." Telegrams are full rate messages and are accepted for immediate transmission with a minimum charge rate of 15 words. Overnight telegrams are usually accepted anytime during the day but are held for transmission until message traffic conditions are slow enough so that they may be transmitted. Usually, they will be sent by the following morning. Overnight telegrams carry the service indicator "NL" for distinction as a message to be handled at the end of the working day. Full rate telegrams carry no service indicator.

The following is an example of a Class E message from a ship to a Navy Class E refile point for Western Union delivery:

```
RTTUZYUW  RULYMIB0002  3001300-UUUU—
    RULYSUU.
ZNR UUUUU
R 271300Z OCT 77
FM USS AMERICA
TO NAVCOMMU CLASS E REFILE WASHINGTON
    DC
BT
UNCLAS //N00000//
MSG CK14 NL COMLE
JACK KENT
144 OAK STREET
WISCONSIN RAPIDS, WI 54494
DAD. NEED TWO HUNDRED DOLLAR LOAN
    FOR CHRISTMAS EXPENSES. PLEASE SEND
    SOON.
JOHN KENT USS AMERICA
BT
#0002
```

The indicator MSG is always transmitted as the first group after the classification line to indicate that this is a Class E message intra Navy or refiled with Western Union. The commercial check (CK) followed by the chargeable word count is transmitted after the indicator MSG. Only the text and any additional material added to the signature are counted as chargeable words in commercially refiled Class E messages. In the example above, the service indicator "NL" designates it as an overnight telegram. The commercial designator "COMLE" is transmitted on all Class E messages to be refiled with the Western Union Telegraph Company. The text follows with the name of the ship or activity of origin as the last words. The name of the ship or activity at the end is chargeable, but the signature is not, as long as no additions are made to the signature. A service number added to the signature, for example, would increase the number of chargeable words.

Class E Rates

Rates for Class E messages filed with one of the authorized Navy transfer points are normally set up on a "flat rate" schedule as determined by agreement between Western Union and COMNAVTELCOM. The rate tables are provided in NTP 9 and are subject to change as promulgated by COMNAVTELCOM. The minimum charge for an overnight telegram is for 100 words of text, and the words in excess of that minimum are charged for on a "per word" basis. The minimum charge for a full rate telegram is for 15 words or less, with extra charges for additional words.

Personnel aboard ships and overseas stations should be kept aware of the availability of Class E message service and the current rates applicable. Personnel should also be encouraged to send the information concerning their telegraphic address to their families. This may ease the burden in contacting them, if the need should arise.

Abstracting Class E Messages

All naval ships, stations, and activities originating Class E messages involving tolls should submit monthly reports under report symbol NAVCOMPT 2101-1 listing all toll messages handled. All reports should be mailed to the Navy Regional Finance Center, Washington, DC 20371. Reports from ships should be mailed by the 5th of each month following handling, and naval stations and activities should mail the reports by the 10th of each month.

The Class E message report should comprise the following:

1. The Class E message abstract form (NAVCOMPT Form 2067).
2. One copy of each Class E message handled, showing complete transmission data.
3. The remittance.

The remittance should be in the form of an exchange-for-cash U.S. Treasury check, U.S. postal money order, or an American Express money order made payable to "The Western Union Telegraph Company, Washington, DC 20005." The check or money order should accompany the report sent to the Navy Regional Finance Center.

Caution must be exercised here by commercial traffic clerks to ensure the check is made payable to Western Union for Class E messages, even though the report (and the check) is mailed to the Navy Regional Finance Center, Washington, DC.

COASTAL HARBOR RADIOTELEPHONE SERVICE

Coastal harbor radiotelephone service is a two-way telephone communication service through a commercial land radiotelephone station between a naval vessel and any telephone on land. This service is provided to meet the needs of ships operating within a few hundred miles of the shore and is known commercially as the coastal harbor service. Except for USNS contract operated vessels, naval vessels using this service are limited to calls originating on the ship. Calls normally are made collect in order to keep shipboard abstracting to a minimum. Incoming calls to the ship (except those necessary to complete shore-ship connections that involve some delay) are not accepted.

The coastal harbor radiotelephone service is authorized for passing official messages when appropriate. Any official message passed via this circuit requires release by an authorized releasing officer.

All U.S. Navy ships are authorized to use this service in peacetime unless otherwise directed by appropriate authority.

ARRANGEMENTS WITH TELEPHONE COMPANY FOR INITIATION OF SERVICE

No prior arrangements are necessary to use this service for collect calls, toll credit card calls, or for calls "billed to third number," (i.e., other than the calling or called party.) If the service is to be used for calls paid aboard ship (as may be the case of USNS contract vessels), the ship or aircraft squadron commander must establish an account with the telephone company representative nearest the home teleport assigned to the unit. The form letter (as shown in fig. 17-4), when filled out, contains all the necessary data to establish a coastal harbor service billing account. Ships desiring to use the Hawaiian coastal ship-to-shore service must first make local arrangements with the Commercial Manager, Hawaiian Telephone Company, Honolulu, Hawaii.

After the account is established (except those established in the Hawaiian area) it covers service through all the coastal harbor stations in the continental United States.

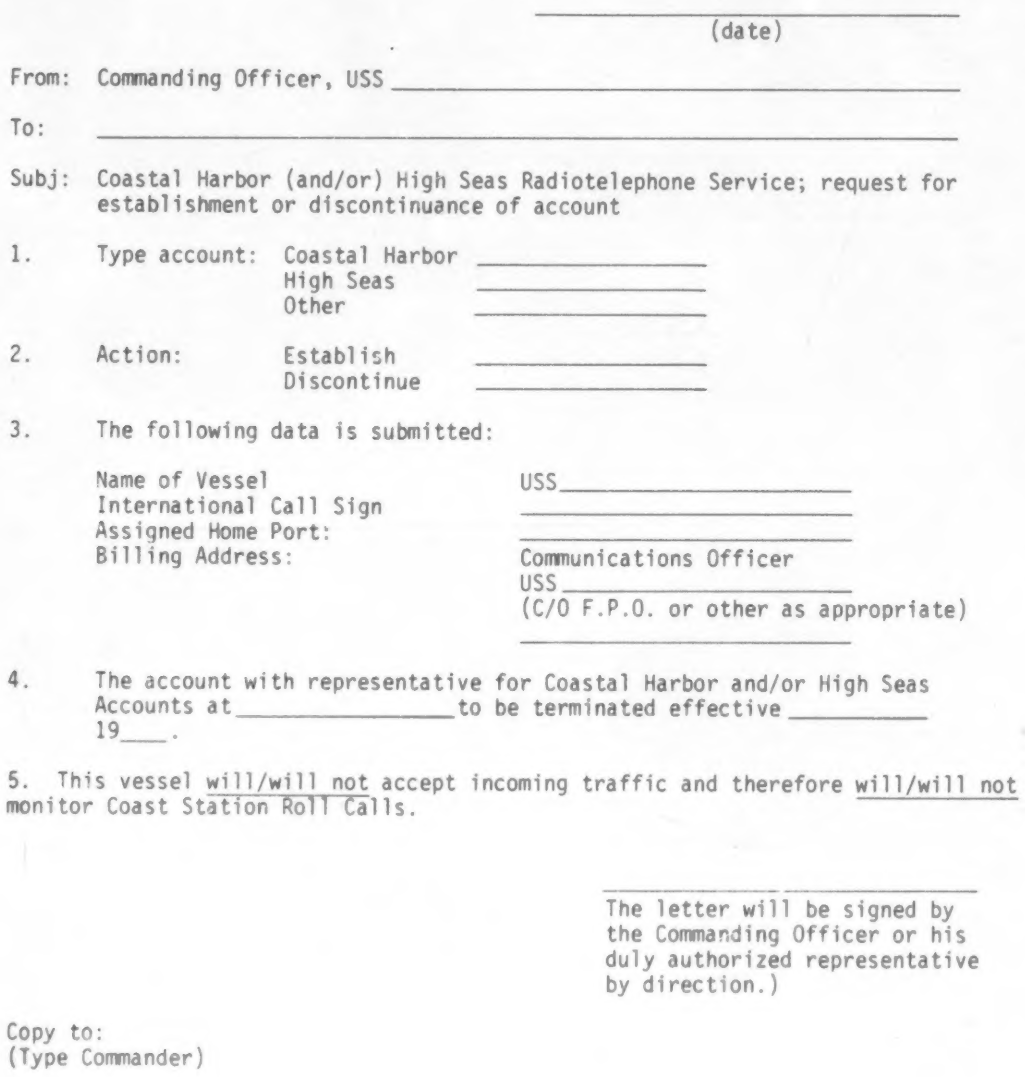
In the event the ship is assigned to a new home port, a new form letter is sent to the telephone company representative nearest the new home port. A copy also is forwarded to the former representative handling the billing account; one letter to establish an account and one to discontinue the old account.

Shipboard Arrangements

Shipboard arrangements for use of telephone service are handled by the communication officer. The communication officer or a person designated by him serves as the shipboard technical operator. He is responsible for all technical details incident to shipboard operation of equipment.

Rates for Service

The charge for service depends upon the location of the ship as well as the land telephone. The coastal waters are divided into rate areas, which are defined by latitude and longitude, as shown in NTP 9. Calls normally are made collect. Charges (toll plus tax) on all calls must be collected when it is impractical to make the call collect. The marine operator will furnish the charges upon request.



____
(date)

From: Commanding Officer, USS ______________________________

To: ______________________________

Subj: Coastal Harbor (and/or) High Seas Radiotelephone Service; request for establishment or discontinuance of account

1. Type account: Coastal Harbor ____________
High Seas ____________
Other ____________

2. Action: Establish ____________
Discontinue ____________

3. The following data is submitted:

Name of Vessel	USS ____________
International Call Sign	____________
Assigned Home Port:	____________
Billing Address:	Communications Officer USS ____________ (C/O F.P.O. or other as appropriate) ____________

4. The account with representative for Coastal Harbor and/or High Seas Accounts at ____________ to be terminated effective ____________ 19___.

5. This vessel will/will not accept incoming traffic and therefore will/will not monitor Coast Station Roll Calls.

____
The letter will be signed by the Commanding Officer or his duly authorized representative by direction.)

Copy to:
(Type Commander)

76.155

Figure 17-4.—Form Letter for Requesting Establishment of Coastal Harbor and High Seas Radiotelephone Service Account.

Equipment

Transmitters: All standard Navy MF/HF transmitters designed for A3 (voice) emission are, if properly tuned and adjusted, adaptable to this service.

Receivers: All standard Navy MF/HF receivers designed for A3 reception are suitable for this service. Accurate tuning to the correct frequency is essential to ensure good service.

Push-to-talk, release-to-listen operation: This method is considered to be the most practical and satisfactory type of operation. However, this method offers difficulties to unpracticed users. It is anticipated that some instruction will be necessary.

Frequencies, station locations, and call signs are listed in the current edition of NTP 9.

How to Place a Call

If you assume that the person desiring to place a call has made necessary arrangements with the communication officer and that transmitting and receiving equipment have been properly adjusted and tuned to the desired shore station frequency, the following procedure is observed for placing and completing a call. The ship's technical operator will—

1. Listen to make certain that the circuit is not in use.
2. If the circuit is clear, call the marine operator by voice. If there is no immediate response, repeat the call after a short interval. Excessive testing, calling, and transmission of signals without identification are forbidden.

Example:

"Norfolk Marine Operator, this is the USS America."

3. When the telephone company marine operator responds, give the name of the ship, coastal rate area in which the ship is located, and the city and land telephone number desired. The marine operator should be requested to provide the time and charges when non-collect calls are made. Example:

> "This is USS America, rate area 2A, calling Minneapolis, Minnesota 336-1095 collect."

4. When the telephone company marine operator has recorded call details and made necessary connections, the circuit is ready for the person making the call. For best results, speak naturally and not too loudly. Also, wait until the other party has finished speaking before starting to talk.
5. Upon completion of the conversation, immediately advise the telephone company marine operator that the call is completed. Example:

"This is USS America. Call completed."

HIGH SEAS RADIOTELEPHONE SERVICE

Ship radiotelephone service through high seas radiotelephone stations provides communication between a ship and a land telephone. Service is furnished through land radiotelephone stations WOO, New York, NY; KMI, Oakland, CA; WOM, Miami, FL; and KQM, Kahuku, Oahu, HI.

Authorization and availability of this service remain the same as for coastal harbor radiotelephone service. Because of the distance involved, however, the provision of service through these stations is subject to transmission, atmospheric, and other limitations.

Ordinarily, service to ships operating near the coast of the United States is furnished through coastal harbor radiotelephone stations established to provide radio communications over relatively short distances. It is contemplated that, in general, ship radiotelephone service through high seas radiotelephone stations will be used by ships operating beyond the normal range of these coastal harbor stations.

CONDITIONS UNDER WHICH SERVICE IS FURNISHED

The conditions under which high seas radiotelephone service is furnished are essentially the same as for coastal harbor stations. An exception is furnishing the station with a general approximation of the bearing of the ship on the shore station in order to assist with selection of the antenna.

Service Charge

Determination of service charge depends upon location of both the ship and the land telephone. The United States is divided into land rate areas by groups of states; the oceans are divided into ocean rate areas defined by latitude and longitude. Land and ocean rate areas are illustrated in NTP 9.

Billing of Service Charges

Normally, all calls are made collect. If it is impossible for all calls to be made collect, then the charges are billed against the coastal harbor telephone service account of the ship.

Difference in Operating Procedures

The traffic procedures to be followed by ships in handling calls through high seas radiotelephone stations differ but slightly from handling calls through a coastal harbor station. The essential differences in dealing with calls are as follows:

1. After the radio circuit is established between the ship and the shore traffic operators, the details of all calls on hand are passed, together with any reports pertaining to calls carried forward from a previous contact period.

2. In dealing with a number of active calls, a definite order of precedence of one call over another should be followed. The basic order in the use of the circuits is that a call on which both parties are immediately available is completed before proceeding with new calls; otherwise, calls are dealt with in the order in which they are booked.

3. To facilitate identification of a particular call where more than one call is active at the same time, the shore traffic operator assigns a serial number to each call.

4. In passing to the ship operator a call, report, or order that necessitates mention of a time of day, the shore traffic operator gives the time in terms of the shore station in all instances.

Frequencies

Operating frequencies for high seas radiotelephone stations are contained in NTP 9.

APPENDIX I

GLOSSARY OF TERMS

ACP — Allied Communications Publication. Provides communications instructions and procedures essential to conducting combined military operations and communications in which two or more Allied nations are involved.

AF — Audio Frequency. A frequency which can be detected as a sound by the human ear. The range of audio frequency extends from approximately 20 to 20,000 Hz.

AFTS — Audio Frequency Tone Shift. Keeping the radio carrier constant and shifting back and forth between two discrete audio frequency tones to produce the MARK/SPACE signals of a teletype channel.

AMPERE — The practical unit of electrical current.

AMPLITUDE — The maximum periodically varying quantity (such as an alternating voltage) as measured from its average or zero values.

AMPLITUDE MODULATION — The process by which the amplitude of the rf carrier wave is varied in accordance with the electrical form of the message. In amplitude modulation, the frequency of the rf carrier remains constant.

ANTENNA — A device used to radiate or intercept radio waves.

ANTENNA LOADING — The process of adding/removing inductance or capacitance of an antenna to make its electrical length adaptable to the radiated or received signal.

ASC — Automatic Switching Center.

ATMOSPHERE — The mixture of gases, chiefly oxygen and nitrogen, that surrounds the earth.

ATTENUATION — A reduction or loss in energy. Attenuation occurs naturally during wave travel through lines, waveguides, spaces, or a medium such as water. Attenuation may be produced intentionally by inserting an attenuator in a circuit or placing an absorbing device in the path of the radiation.

AUTODIN — Automatic Digital Network. A world-wide automatic communication system that provides automatic data service. It is a general purpose network of the defense communications system.

AUTOVON — Automatic Voice Network. An automatic circuit switching network that provides voice interconnection between military and other installations. Navy afloat and aircraft units are provided access to AUTOVON.

AUTOSEVOCOM — Automatic Secure Voice Communication Network.

BAUD — A unit of telegraph signaling speed. The speed in bauds is the number of code elements (marks and spaces) per second.

BIDIRECTIONAL — Response in two opposite directions.

BOOK MESSAGE — A message destined for two or more addressees but is of such a nature that the drafter considers that no addressee need or should be informed of any other addressee.

CALIBRATING — To determine, by measurement or comparison with a standard, the correct value of each scale reading on a meter or other device or to determine the settings of a control that correspond to particular values of voltage, current, frequency, or some other quantity.

CARRIER—The unmodulated radio wave produced by a transmitter.

CIC—Meaning #1: Combat Information Center. Meaning #2: Content Indicator Code. The intended meaning will be readily apparent to the reader by the contents of the subject matter.

CODRESS—Message type where the originator and all addressees are included in the encrypted text.

COMPROMISE—The known or suspected exposure of classified information or material to an unauthorized person.

COMSEC MATERIAL—All material, including publications, devices, equipment, or apparatus essential to the encryption, decryption, or authentication of telecommunications.

CONDUCTIVITY—The ability of a material to conduct electric current.

CONFIDENTIAL—A classification assigned to information or material. The unauthorized disclosure of Confidential information could reasonably be expected to cause damage to the national security.

CONTROLLED AREA—An area within which uncontrolled movement does not permit access to classified information, and is designed for the principal purpose of providing administrative control, safety, or a "buffer" area for limited or exclusion areas.

CRITICAL FREQUENCY—The maximum frequency below which a radio wave will be refracted by an ionospheric layer at vertical incidence at a given time. Higher frequencies will penetrate the layer. Also called penetration frequency.

CURRENT—A movement of electrons or charges along a conductor.

DECIBEL—A unit used to relate the ratio of two power levels. Each three decibels (dB) is equivalent to a 2-to-1 power ratio.

DIFFRACTION—The apparent bending of a wave around the edges of an object. It is caused by interference between wave components scattered by the boundaries of the object.

DIRECT WAVE—A radio wave that is propagated in a straight line from the transmitter to the receiver.

DISTORTION—An undesired change in waveforms.

DUCTING—A phenomenon in which radio waves are trapped in a layer or duct of warm air. The duct acts as a wave guide and may cause the wave to be received over abnormally long distances.

EHF—Extremely High Frequency (30-300 GHz)

ELECTROMAGNETIC ENERGY—Energy associated with radio waves, heat waves, and other types of electromagnetic radiation.

EMCON—Electromagnetic Emission Control. Effective management of emissions to obtain the maximum tactical advantage.

ENCRYPTION—The process of converting intelligible information to an unintelligible form for transmission.

EXCLUSION AREA—An area containing classified information of a nature that access to the space would constitute access to the information contained in the space.

EXEMPT—An element of a collective call sign who is not an intended addressee of the message. Designated by the prosign XMT.

FACSIMILE (FAX)—A system of communication in which a photograph, map, or other fixed graphic material is scanned and the information converted into signals for transmission by wire or radio to a facsimile receiver at a remote point.

FADING—Variations, usually gradual, in the field strength of a radio signal that are caused by changes in the transmission path or medium.

FEEDBACK—The return of a portion of the output of a circuit to its input.

FIELD STRENGTH—The strength of an electric, magnetic, or electromagnetic field at a given point.

FREQUENCY—The number of complete cycles per unit of time for periodic phenomena, such as alternating current, sound waves, or vibrating systems.

FREQUENCY DIVERSITY—Diversity reception which involves the use of two or more carrier frequencies, each having the same modulation, to take advantage of the fact that fading does not occur simultaneously on different frequencies.

FREQUENCY MODULATION—Modulation in which the instantaneous frequency of the carrier is caused to change by an amount proportional to the instantaneous amplitude of the modulating wave.

FREQUENCY OF OPTIMUM TRAFFIC (FOT)—The frequency which is capable of providing the communications between two specific points for a given hour, depending upon the condition of the ionosphere.

FSK—Frequency Shift Keying. A variation of frequency modulation. The rf carrier frequency is shifted above and below the carrier frequency of the transmitter corresponding to the marks and spaces of a teletype signal.

FREQUENCY SPECTRUM—The entire range of frequencies from sound waves up through the various degrees of light waves.

GIGAHERTZ—Kilomegahertz. Giga is a prefix representing 10^9.

GROUNDWAVE—Refers to those types of radio transmissions that do not make use of refractions from the ionosphere. Direct waves, ground-reflected waves, surface waves, and tropospheric waves are all components of the ground wave.

GROUND REFLECTED WAVE—The component of the ground wave that reaches the receiving antenna after being reflected from the ground or the sea.

HERTZ—Term used to indicate cycles per second. Example: Hz, KHz, MHz, etc.

HICOM—Navy High Command world-wide voice network.

ICSB—Interim Command Switchboard. A system providing an interface between voice radio circuits and shore telephone systems.

INCIDENT WAVE—A wave that impinges on a discontinuity or on a medium having unlike propagation characteristics. Also, a current or voltage wave that is traveling through a transmission line in a direction from source to load.

INFRARED—Electromagnetic radiation that lies in the frequency range just below that of visible red light.

IONOSPHERE—The outer region of the earth's atmosphere where ions and electrons are present in quantities sufficient to affect the propagation of radio waves. It begins about 30 miles up and extends to about 250 miles.

ISB—Independent Side Band. Independent sideband is radiation of a reduced rf carrier on which one intelligence is used to modulate the upperside and another intelligence is used to modulate the lowerside.

ISOTROPIC ANTENNA—A hypothetical antenna that radiates or receives signals equally well in all directions.

JANAP—Joint Army-Navy-Air Force Publication.

kHz—Kilo Hertz (1000 Hertz).

LDMX—Local Digital Message Exchange.

LIMITED AREA—An area containing classified information in which uncontrolled movement would permit access to such classified information.

LOBE—The "tear drop" shape radiation pattern of a directional antenna. The direction of maximum radiation coincides with the axis of the major lobe. All other lobes in the pattern are called minor lobes.

LOWEST USABLE FREQUENCY (LUF)—The lowest high frequency which is dependent upon equipment characteristics that is effective at a specified time for ionospheric propagation of radio waves between two specified points.

LSB—Lower sideband. The band of frequencies in an amplitude modulated rf wave which extends from the rf carrier frequency to 3 kHz below the rf carrier frequency.

MAXIMUM USABLE FREQUENCY (MUF)—The highest operating frequency that is reflected from the ionosphere for a point-to-point path for 50% of the days in a given month.

MICROWAVE—Wavelengths in the microwave spectrum from about 30 cm to 0.3 cm.

MINIMIZE—The condition necessary to reduce voice and record traffic so that essential traffic may be efficiently handled.

MHz—Mega Hertz. (1,000,000 Hertz)

MPDS—Message Processing and Distribution System.

NAVCAMS—Naval Communications Area Master Station, control coordination of all naval communications within a NAVCOMMAREA.

NAVCOMMSTA—Naval Communications Station. An activity which operates and maintains those facilities, systems, equipments, and devices necessary to provide requisite fleet support and fixed communications services for a specific area.

NAVCOMMU—Naval Communications Unit. An activity smaller in personnel, resources, and facilities than a NAVCOMMSTA and which is assigned a more limited or specialized functional mission.

NAVCOMPARS—Naval Communications Processing and Routing System.

NAVRADSTA—Naval Radio Station. A NAVRADSTA may be either transmitter or receiver and provides the NAVCOMMSTA/NAVCOMMU with transmitting and receiving facilities.

NOISE—An undesired electric disturbance that tends to interfere with the normal reception or processing of a desired signal.

NWPL—Naval Warfare Publications Library.

OFF-LINE—The term used to describe the process of encrypting messages for transmission using manual procedures and having the message in an encrypted form when handled by the operator.

OHM—The unit of electric resistance. A current of 1 ampere will flow through a resistance of 1 ohm when a voltage of 1 volt is applied.

OMNIDIRECTIONAL—Radiating or receiving evenly in all directions.

ON-LINE—The term used to describe the method of automatically encrypting a message as it is transmitted through a classified crypto system.

OSCILLATOR—A circuit that generates alternating current at a frequency determined by the values of its electrical components.

PARABOLIC ANTENNA—A directional microwave antenna using some form of parabolic reflector to give improved sensitivity and directivity.

PEAK ENVELOPE POWER (PEP)—The average power supplied to an antenna by a single sideband transmitter.

PHASE—The position of a point on the waveform of an alternating or other periodic quantity with respect to the beginning of the cycle.

PHASE MODULATION—Modulation in which instantaneous phase of the carrier wave is caused to shift from its normal position by an amount proportional to the instantaneous amplitude of the modulating wave.

POWER—The rate at which electrical energy is supplied to or taken from a device, measured in watts.

PRO FORMA MESSAGE—A message with strictly formatted textual elements. Information in these messages always appears in the same location, as in MOVREPS and CASREPS.

PROPAGATION—The method by which electromagnetic or sound waves travel through a conducting medium.

"Q" MESSAGE—The classified portions of the navigational warning system of Allied nations.

RADIO FREQUENCY (rf)—A frequency at which coherent electromagnetic energy is useful for communications purposes.

REFLECTOR—A system of metallic rods, screens, or surfaces used with an antenna to give it a directional effect.

REFRACT—The bending of heat, light, radar, radio, or sound waves as they pass obliquely from one medium to another in which the velocity of propagation is different.

RELATIONSHIP OF VOLTAGE, CURRENT, RESISTANCE, AND POWER—Voltage is the force that moves electrons, creating current flow. Current flow is directly proportional to the amount of applied voltage. Resistance is the opposition a circuit offers to the flow of current. In a circuit containing only resistance, power is equal to the product of the current and the voltage.

RELEASING OFFICER—The commanding officer or officers designated by the commanding officer with the authority to release outgoing messages for the command.

RESISTANCE—The opposition that a device or material offers to the flow of electrical current. Resistance is measured in ohms.

RESONANCE—The condition existing in a circuit when the frequency of an applied voltage or current equals the natural or resonant frequency of the circuit.

RFCS—Radio Frequency Carrier Shift. See the definition for FSK.

RHOMBIC ANTENNA—A horizontal antenna having the shape of a diamond or rhombus. Usually fed at one apex and terminated with a resistance or impedance at the opposite apex.

SECRET—A classification referring to national security information. The unauthorized disclosure of Secret material could reasonably be expected to cause serious damage to the national security.

SELECTIVITY—A merit figure that expresses the ability of a circuit or device to respond to an input quantity.

SENSITIVITY—The minimum input signal required in a radio receiver to produce a specified output signal having a specified signal-to-noise ratio.

SHF—Super High Frequency (3-30 GHz).

SKIP DISTANCE—The shortest distance from the transmitter at which a given sky wave will be returned to the earth after reflection from the ionosphere.

SKIP ZONE—An area beyond the ground-wave reception region, within which no radio signals are received. Beyond the skip zone, sky-wave signals may be received.

SKY WAVE—A radio wave that travels upward and away from the earth. It may be returned to the earth by refraction from the ionosphere.

SPACE DIVERSITY—Radio reception involving the use of two or more antennas located several wavelengths apart. These antennas feed individual receivers whose outputs are combined.

SPACE WAVE—The component of a radio wave that travels through space from the transmitting antenna to the receiving antenna. One part of the space wave travels directly to the receiving antenna while the other part is reflected off the earth.

STANDING WAVES—A stationary wave which builds up on a transmission line when some of the energy being fed by the source is reflected back from the load. The incident and reflected energy reinforce at fixed points and build up a standing wave.

STRATOSPHERE—A layer of the earth's atmosphere above the troposphere extending from about 7 miles to about 50 miles above the earth. The temperature is essentially constant in the stratosphere.

SUNSPOT—A dark spot observed on the sun. Such observations are usually followed by magnetic storms near the earth. These storms affect radio communications at the lower frequencies.

SURFACE WAVE—A wave that travels along the surface of the earth. The distance the surface wave travels from the transmitting antenna is governed by the power generated from the transmitter.

TOP SECRET—A classification referring to national security information. The unauthorized disclosure of Top Secret material could reasonably be expected to cause exceptionally grave damage to the national security.

TROPOSPHERE—The portion of the earth's atmosphere extending upward from the surface of the earth up to about 6 miles in which temperature generally decreases with altitude, clouds form, and convection exists.

TUNING—Adjusting circuits for best performance at a desired frequency.

TWX—A commercial teletypewriter exchange.

UHF—Ultra-High Frequency. (300-3000 MHz)

UNIDIRECTIONAL—Flowing in only one direction, such as d.c. current. Radiating in only one direction.

USB—Upper Side Band. The band of frequencies in an amplitude modulated rf wave which extends from the rf carrier to 3 kHz above the rf carrier.

VHF—Very High Frequency. (30-300 MHz)

VLF—Very Low Frequency. (below 30 kHz)

VOLT—The unit of voltage, potential difference, and electromotive force. One volt will cause a current of one ampere to flow through a resistance of one ohm.

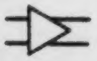
VOLTAGE—The term used to designate a difference in electrical pressure between two points in a circuit which is capable of producing a flow of current.

WATT—The unit of electrical power. In a d.c. circuit, the power (in watts) is equal to the voltage (in volts) multiplied by the current (in amperes).

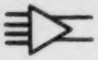
APPENDIX II
ELECTRONICS SYMBOLS

AMPLIFIER (2) *

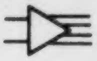
GENERAL



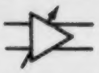
WITH TWO INPUTS



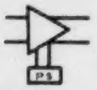
WITH TWO OUTPUTS



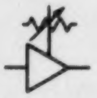
WITH ADJUSTABLE GAIN



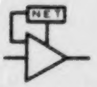
WITH ASSOCIATED POWER SUPPLY



WITH ASSOCIATED ATTENUATOR



WITH EXTERNAL FEEDBACK PATH

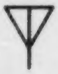


AMPLIFIER LETTER COMBINATIONS (amplifier-use identification in symbol if required)

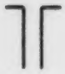
BDG	BRIDGING
BST	BOOSTER
CMP	COMPRESSION
DC	DIRECT CURRENT
EXP	EXPANSION
LIM	LIMITING
MON	MONITORING
PGM	PROGRAM
PRE	PRELIMINARY
PWR	POWER
TRQ	TORQUE

ANTENNA (3)

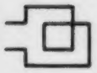
GENERAL



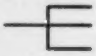
DIPOLE



LOOP

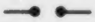


COUNTERPOISE

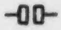


ARRESTER, LIGHTNING (4)

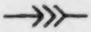
GENERAL



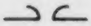
CARBON BLOCK



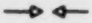
ELECTROLYTIC OR ALUMINUM CELL



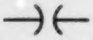
HORN GAP



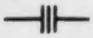
PROTECTIVE GAP



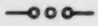
SPHERE GAP



VALVE OR FILM ELEMENT



MULTIGAP

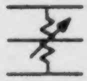


ATTENUATOR, FIXED (see PAD) (57)

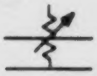
(same symbol as variable attenuator, without variability)

ATTENUATOR, VARIABLE (5)

BALANCED

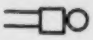


UNBALANCED

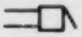


AUDIBLE SIGNALING DEVICE (6)

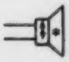
BELL, ELECTRICAL; RINGER, TELEPHONE



BUZZER



HORN, ELECTRICAL; LOUDSPEAKER, SIREN; UNDERWATER SOUND HYDROPHONE, PROJECTOR OR TRANSDUCER

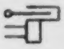


HORN, LETTER COMBINATIONS (if required)

*HN	HORN, ELECTRICAL
*HW	HOWLER
*LS	LOUDSPEAKER
*SN	SIREN
†EM	ELECTROMAGNETIC WITH MOVING COIL
†EMN	ELECTROMAGNETIC WITH MOVING COIL AND NEUTRALIZING WINDING
†MG	MAGNETIC ARMATURE
†PM	PERMANENT MAGNET WITH MOVING COIL

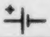
(identification replaces (*) asterisk and (†) dagger)

SOUNDER, TELEGRAPH

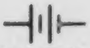


BATTERY (7)

GENERALIZED DIRECT CURRENT SOURCE, ONE CELL

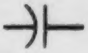


MULTICELL

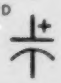


CAPACITOR (8)

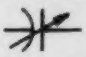
GENERAL



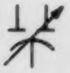
POLARIZED



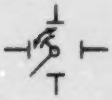
ADJUSTABLE OR VARIABLE



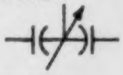
CONTINOUSLY ADJUSTABLE OR VARIABLE DIFFERENTIAL



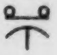
PHASE-SHIFTER



SPLIT-STATOR

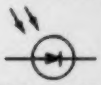


FEED-THROUGH

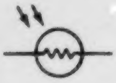


CELL, PHOTOSENSITIVE (Semiconductor) (9)

ASYMMETRICAL PHOTOCONDUCTIVE TRANSDUCER



SYMMETRICAL PHOTOCONDUCTIVE TRANSDUCER

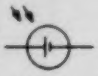


* NUMBER IN PARENTHESES INDICATES LOCATION OF SYMBOL IN MIL-STD PUBLICATION

13.5A

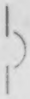
391

PHOTOVOLTAIC TRANSDUCER; SOLAR CELL

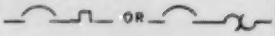


CIRCUIT BREAKER (11)

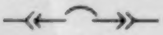
GENERAL



WITH MAGNETIC OVERLOAD

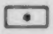


DRAWOUT TYPE



CIRCUIT ELEMENT (12)

GENERAL



CIRCUIT ELEMENT LETTER COMBINATIONS (replaces (*) asterisk)

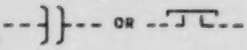
EG	EQUALIZER
FAX	FACSIMILE SET
FL	FILTER
FL-BE	FILTER, BAND ELIMINATION
FL-BP	FILTER, BAND PASS
FL-HP	FILTER, HIGH PASS
FL-LP	FILTER, LOW PASS
PS	POWER SUPPLY
RG	RECORDING UNIT
RU	REPRODUCING UNIT
DIAL	TELEPHONE DIAL
TEL	TELEPHONE STATION
TPR	TELEPRINTER
TTY	TELETYPEWRITER

ADDITIONAL LETTER COMBINATIONS (symbols preferred)

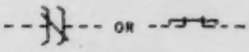
AR	AMPLIFIER
AT	ATTENUATOR
C	CAPACITOR
CB	CIRCUIT BREAKER
HS	HANDSET
I	INDICATING OR SWITCH BOARD LAMP
L	INDUCTOR
J	JACK
LS	LOUDSPEAKER
MIC	MICROPHONE
OSC	OSCILLATOR
PAD	PAD
P	PLUG
HT	RECEIVER, HEADSET
K	RELAY
R	RESISTOR
S	SWITCH OR KEY SWITCH
T	TRANSFORMER
WR	WALL RECEPTACLE

CLUTCH; BRAKE (14)

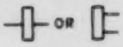
DISENGAGED WHEN OPERATING MEANS IS DE-ENERGIZED



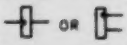
ENGAGED WHEN OPERATING MEANS IS DE-ENERGIZED



COIL, RELAY and OPERATING (16)

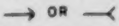


SEMICIRCULAR DOT INDICATES INNER END OF WIRING

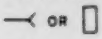


CONNECTOR (18)

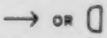
ASSEMBLY, MOVABLE OR STATIONARY PORTION; JACK, PLUG, OR RECEPTACLE



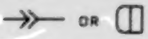
JACK OR RECEPTACLE



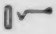
PLUG



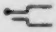
SEPARABLE CONNECTORS



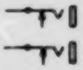
TWO-CONDUCTOR SWITCHBOARD JACK



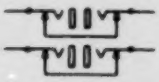
TWO-CONDUCTOR SWITCHBOARD PLUG



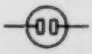
JACKS NORMALLED THROUGH ONE WAY



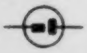
JACKS NORMALLED THROUGH BOTH WAYS



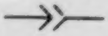
2-CONDUCTOR NONPOLARIZED, FEMALE CONTACTS



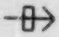
2-CONDUCTOR POLARIZED, MALE CONTACTS



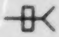
WAVEGUIDE FLANGE



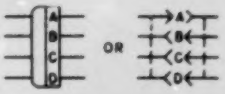
PLAIN, RECTANGULAR



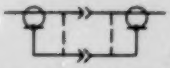
CHOKE, RECTANGULAR



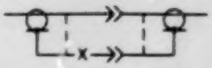
ENGAGED 4-CONDUCTOR; THE PLUG HAS 1 MALE AND 3 FEMALE CONTACTS, INDIVIDUAL CONTACT DESIGNATIONS SHOWN



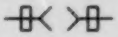
COAXIAL, OUTSIDE CONDUCTOR SHOWN CARRIED THROUGH



COAXIAL, CENTER CONDUCTOR SHOWN CARRIED THROUGH; OUTSIDE CONDUCTOR NOT CARRIED THROUGH

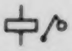


MATED CHOCK FLANGES IN RECTANGULAR WAVEGUIDE

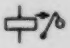


COUNTER, ELECTROMAGNETIC; MESSAGE REGISTER (26)

GENERAL

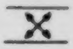


WITH A MAKE CONTACT



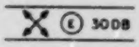
COUPLER, DIRECTIONAL (27)

(common coaxial/waveguide usage)



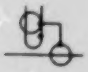
(common coaxial/waveguide usage)

E-PLANE APERTURE-COUPLING, 30-DECIBEL TRANSMISSION LOSS

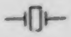


COUPLING (28)

BY LOOP FROM COAXIAL TO CIRCULAR WAVEGUIDE, DIRECT-CURRENT GROUNDS CONNECTED

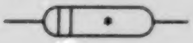


CRYSTAL, PIEZO-ELECTRIC (62)

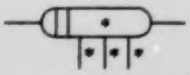


DELAY LINE (31)

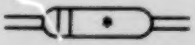
GENERAL



TAPPED DELAY

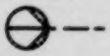


BIFILAR SLOW-WAVE STRUCTURE (commonly used in traveling-wave tubes)



(length of delay indication replaces (*) asterisk)

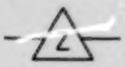
DETECTOR, PRIMARY; MEASURING TRANSDUCER (30) (see HALL GENERATOR and THERMAL CONVERTER)



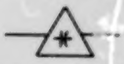
DISCONTINUITY (33)

(common coaxial/waveguide usage)

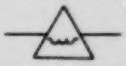
EQUIVALENT SERIES ELEMENT, GENERAL



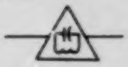
CAPACITIVE REACTANCE



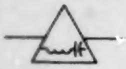
INDUCTIVE REACTANCE



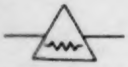
INDUCTANCE-CAPACITANCE CIRCUIT, INFINITE REACTANCE AT RESONANCE



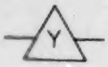
INDUCTANCE-CAPACITANCE CIRCUIT, ZERO REACTANCE AT RESONANCE



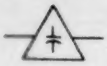
RESISTANCE



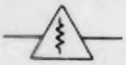
EQUIVALENT SHUNT ELEMENT, GENERAL



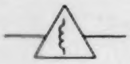
CAPACITIVE SUSCEPTANCE



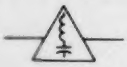
CONDUCTANCE



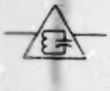
INDUCTIVE SUSCEPTANCE



INDUCTANCE-CAPACITANCE CIRCUIT, INFINITE SUSCEPTANCE AT RESONANCE

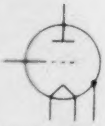


INDUCTANCE-CAPACITANCE CIRCUIT, ZERO SUSCEPTANCE AT RESONANCE

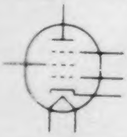


ELECTRON TUBE (34)

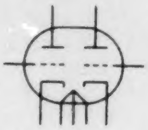
TRIODE



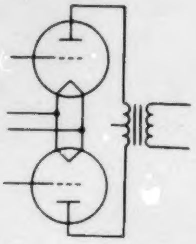
PENTODE, ENVELOPE CONNECTED TO BASE TERMINAL



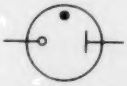
TWIN TRIODE, EQUIPOTENTIAL CATHODE



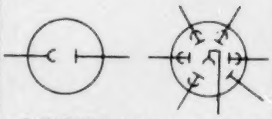
TYPICAL WIRING FIGURE TO SHOW TUBE SYMBOLS PLACED IN ANY CONVENIENT POSITION



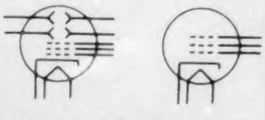
RECTIFIER; VOLTAGE REGULATOR
(see LAMP, GLOW)



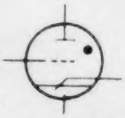
PHOTOTUBE, SINGLE AND MULTIPLIER



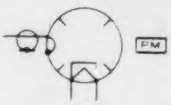
CATHODE-RAY TUBE, ELECTROSTATIC AND MAGNETIC DEFLECTION



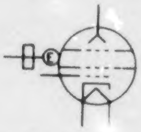
MERCURY-POOL TUBE, IGNITOR AND CONTROL GRID (see RECTIFIER)



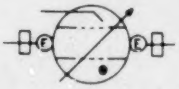
RESONANT MAGNETRON, COAXIAL OUTPUT AND PERMANENT MAGNET



REFLEX KLYSTRON, INTEGRAL CAVITY, APERTURE COUPLED

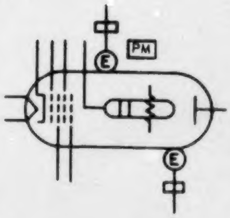


TRANSMIT-RECEIVE (TR) TUBE GAS FILLED, TUNABLE INTEGRAL CAVITY, APERTURE COUPLED, WITH STARTER



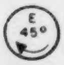
TRAVELING-WAVE TUBE (typical)

FORWARD-WAVE TRAVELING-WAVE-TUBE AMPLIFIER SHOWN WITH FOUR GRIDS, HAVING SLOW-WAVE STRUCTURE WITH ATTENUATION, MAGNETIC FOCUSING BY EXTERNAL PERMANENT MAGNET, rf INPUT AND rf OUTPUT COUPLING EACH E-PLANE APERTURE TO EXTERNAL RECTANGULAR

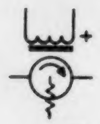


FERRITE DEVICES (100)

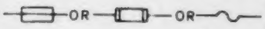
FIELD POLARIZATION ROTATOR



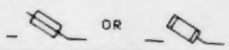
FIELD POLARIZATION AMPLITUDE MODULATOR



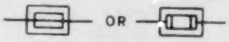
FUSE (36)



HIGH-VOLTAGE PRIMARY CUT-OUT, DRY

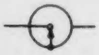


HIGH-VOLTAGE PRIMARY CUT-OUT, OIL

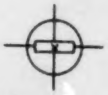


GOVERNOR (contact-making) (37)

CONTACTS SHOWN HERE AS CLOSED

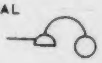


HALL GENERATOR (39)

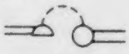


HANDSET (40)

GENERAL

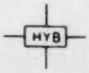


OPERATOR'S SET WITH PUSH-TO-TALK SWITCH

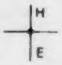


HYBRID (41)

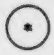
GENERAL



JUNCTION
(common coaxial/waveguide usage)

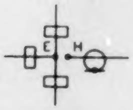


CIRCULAR



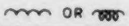
(E, H or HE transverse field indicators replace (*) asterisk)

RECTANGULAR WAVEGUIDE AND COAXIAL COUPLING



INDUCTOR (42)

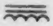
GENERAL



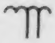
13.5C

Appendix II—MECHANICAL AND ELECTRICAL SYMBOLS

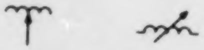
MAGNETIC CORE



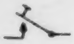
TAPPED



ADJUSTABLE, CONTINUOUSLY ADJUSTABLE

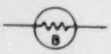


KEY, TELEGRAPH (43)

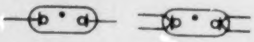


LAMP (44)

BALLAST LAMP; BALLAST TUBE

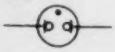


LAMP, FLUORESCENT, 2 AND 4 TERMINAL

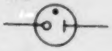


LAMP, GLOW, NEON LAMP

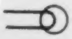
A-C



D-C



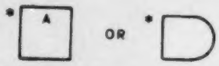
LAMP, INCANDESCENT



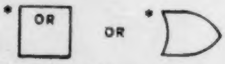
INDICATING LAMP, SWITCHBOARD LAMP
(see VISUAL SIGNALING DEVICE)

LOGIC (see 806B and Y32-14)
(including some duplicate symbols, left and right-hand symbols are not mixed)

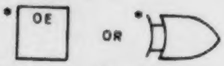
AND function



OR function



EXCLUSIVE-OR function



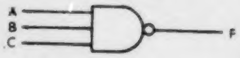
((*) input side of logic symbols in general)

CONDITION INDICATORS

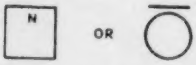
STATE (logic negation)

A LOGIC NEGATION OUTPUT BECOMES 1-STATE IF AND ONLY IF THE INPUT IS NOT 1-STATE

AN AND FUNC. WHERE OUTPUT IS LOW IF AND ONLY IF ALL INPUTS ARE HIGH

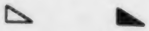


ELECTRIC INVERTER



(elec. invtr. output becomes 1-state if and only if the input is 1-state)
(elec. invtr. output is more pos. if and only if input is less pos.)

LEVEL (relative)

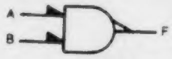


1-STATE IS LESS +

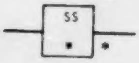
1-STATE IS MORE +

(symbol is a rt. triangle pointing in direction of flow)

AN AND FUNC. WITH INPUT 1-STATES AT MORE POS. LEVEL AND OUTPUT 1-STATE AT LESS POS. LEVEL

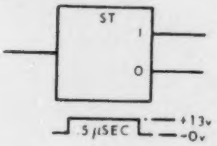


SINGLE SHOT (one output)

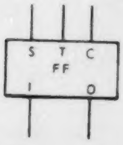


(waveform data replaces inside/outside (*))

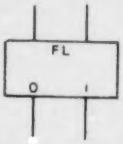
SCHMITT TRIGGER, WAVEFORM AND TWO OUTPUTS



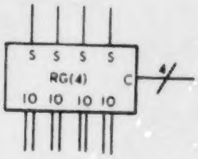
FLIP-FLOP, COMPLEMENTARY



FLIP-FLOP, LATCH

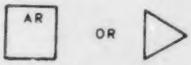


REGISTER



(binary register denoting four flip-flops and bits)

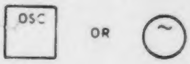
AMPLIFIER (see AMPLIFIER)



CHANNEL PATH(s) (see PATH, TRANSMISSION)

MAGNETIC HEADS (see PICK-UP HEAD)

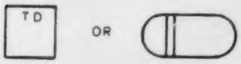
OSCILLATOR (see OSCILLATOR)



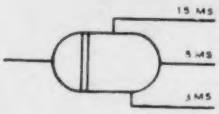
RELAY, CONTACTS (see CONTACT, ELECTRICAL) RELAY, ELECTROMAGNETIC (see RELAY COIL RECOGNITION

SIGNAL FLOW (see DIRECTION OF FLOW)

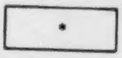
TIME DELAY (see DELAY LINE)



TIME DELAY WITH TYPICAL DELAY TAPS



FUNCTIONS NOT OTHERWISE SYMBOLIZED



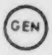
(identification replaces (*))

LOGIC LETTER COMBINATIONS

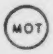
S	SET
C	CLEAR (reset)
T	TOGGLE (trigger)
(N)	NUMBER OF BITS
BO	BLOCKING OSCILLATOR
CF	CATHODE FOLLOWER
EF	EMITTER FOLLOWER
FF	FLIP-FLOP
SS	SINGLE SHOT
ST	SCHMITT TRIGGER
RG(N)	REGISTER (N stages)
SR	SHIFT REGISTER

MACHINE, ROTATING (46)

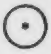
GENERATOR



MOTOR



METER, INSTRUMENT (48)



(identification replaces (*) asterisk)

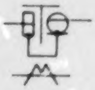
METER LETTER COMBINATIONS

A	AMMETER
AH	AMPERE-HOUR
CMA	CONTACT-MAKING (or breaking) AMMETER
CMC	CONTACT-MAKING (or breaking) CLOCK
CMV	CONTACT-MAKING (or breaking) VOLTMETER
CRO	OSCILLOSCOPE OR CATHODE-RAY OSCILLOGRAPH
DB	DB (decibel) METER
DBM	DBM (decibels referred to 1 milliwatt) METER
DM	DEMAND METER
DTR	DEMAND-TOTALIZING RELAY
F	FREQUENCY METER
G	GALVANOMETER
GD	GROUND DETECTOR
I	INDICATING
INT	INTEGRATING
μA or UA	MICROAMMETER
MA	MILLIAMMETER
NM	NOISE METER
OHM	OHMMETER
OP	OIL PRESSURE

MODE TRANSDUCER (53)

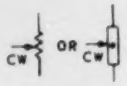
(common coaxial/waveguide usage)

TRANSDUCER FROM RECTANGULAR WAVEGUIDE TO COAXIAL WITH MODE SUPPRESSION, DIRECT-CURRENT GROUNDS CONNECTED



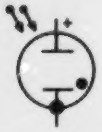
MOTION, MECHANICAL (54)

ROTATION APPLIED TO A RESISTOR



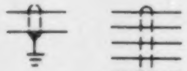
(identification replaces (*) asterisk)

NUCLEAR-RADIATION DETECTOR, GAS FILLED; IONIZATION CHAMBER; PROPORTIONAL COUNTER TUBE;
GEIGER-MULLER COUNTER TUBE (50) (see RADIATION-SENSITIVITY INDICATOR)



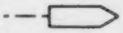
PATH, TRANSMISSION (58)

CABLE; 2-CONDUCTOR, SHIELD GROUNDED AND 5-CONDUCTOR SHIELDED

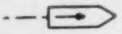


PICKUP HEAD (61)

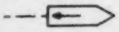
GENERAL



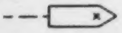
WRITING; RECORDING



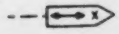
READING; PLAYBACK



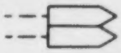
ERASING



WRITING, READING, AND ERASING

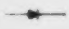


STEREO

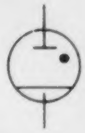


RECTIFIER (65)

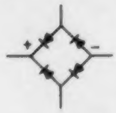
SEMICONDUCTOR DIODE; METALLIC RECTIFIER; ELECTROLYTIC RECTIFIER; ASYMMETRICAL VARISTOR



MERCURY-POOL TUBE POWER RECTIFIER

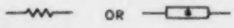


FULLWAVE BRIDGE-TYPE

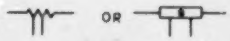


RESISTOR (68)

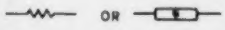
GENERAL



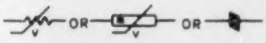
TAPPED



HEATING

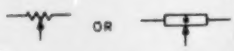


SYMMETRICAL VARISTOR RESISTOR, VOLTAGE SENSITIVE (silicon carbide, etc.)

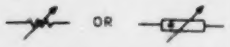


(identification marks replace (*) asterisk)

WITH ADJUSTABLE CONTACT



ADJUSTABLE OR CONTINUOUSLY ADJUSTABLE (variable)

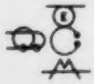


(identification replaces (*) asterisk)

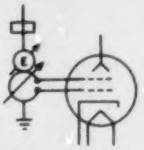
RESONATOR, TUNED CAVITY (71)

(common coaxial/waveguide usage)

RESONATOR WITH MODE SUPPRESSION COUPLED BY AN E-PLANE APERTURE TO A GUIDED TRANSMISSION PATH AND BY A LOOP TO A COAXIAL PATH

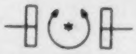


TUNABLE RESONATOR WITH DIRECT-CURRENT GROUND CONNECTED TO AN ELECTRON DEVICE AND ADJUSTABLY COUPLED BY AN E-PLANE APERTURE TO A RECTANGULAR WAVEGUIDE



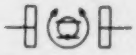
ROTARY JOINT, RF (COUPLER) (72)

GENERAL; WITH RECTANGULAR WAVEGUIDE

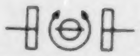


(transmission path recognition symbol replaces (*) asterisk)

COAXIAL TYPE IN RECTANGULAR WAVEGUIDE

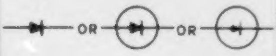


CIRCULAR WAVEGUIDE TYPE IN RECTANGULAR WAVEGUIDE

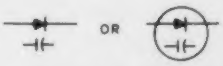


SEMICONDUCTOR DEVICE (73)
(Two Terminal, diode)

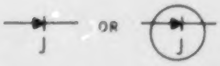
SEMICONDUCTOR DIODE; RECTIFIER



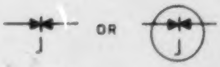
CAPACITIVE DIODE (also Varicap, Varactor, reactance diode, parametric diode)



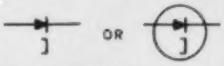
BREAKDOWN, DIODE, UNIDIRECTIONAL (also backward diode, avalanche diode, voltage regulator diode, Zener diode, voltage refer-diode)



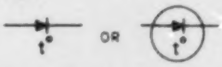
BREAKDOWN DIODE, BIDIRECTIONAL AND BACKWARD DIODE (also bipolar voltage limiter)



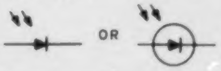
TUNNEL DIODE (also Esaki diode)



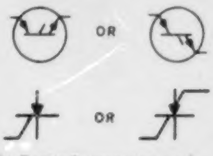
TEMPERATURE-DEPENDENT DIODE



PHOTODIODE (also solar cell)

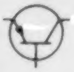


SEMICONDUCTOR DIODE, PNPN SWITCH (also Shockley diode, four-layer diode and SCR).

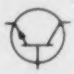


(Multi-Terminal, transistor, etc.)

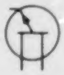
PNP TRANSISTOR



NPN TRANSISTOR

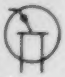


UNIJUNCTION TRANSISTOR, N-TYPE BASE

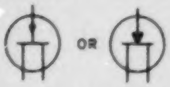


13.5E

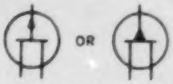
UNIJUNCTION TRANSISTOR, P-TYPE BASE



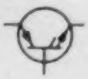
FIELD-EFFECT TRANSISTOR, N-TYPE BASE



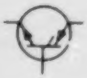
FIELD-EFFECT TRANSISTOR, P-TYPE BASE



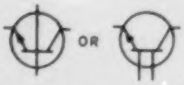
SEMICONDUCTOR TRIODE, PNPN-TYPE SWITCH



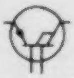
SEMICONDUCTOR TRIODE, NPNP-TYPE SWITCH



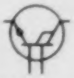
NPN TRANSISTOR, TRANSVERSE-BIASED BASE



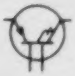
PNIP TRANSISTOR, OHMIC CONNECTION TO THE INTRINSIC REGION



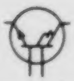
NPIN TRANSISTOR, OHMIC CONNECTION TO THE INTRINSIC REGION



PNIN TRANSISTOR, OHMIC CONNECTION TO THE INTRINSIC REGION

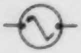


NPIP TRANSISTOR, OHMIC CONNECTION TO THE INTRINSIC REGION

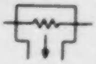


SQUIB (75)

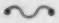
EXPLOSIVE



IGNITER



SENSING LINK, FUSIBLE LINK OPERATED

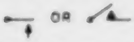


SWITCH (76)

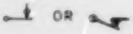
PUSH BUTTON, CIRCUIT CLOSING (make)

PUSH BUTTON, CIRCUIT OPENING (break)

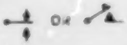
NONLOCKING, MOMENTARY CIRCUIT CLOSING (make)



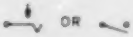
NONLOCKING, MOMENTARY CIRCUIT OPENING (break)



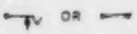
TRANSFER



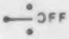
LOCKING, CIRCUIT CLOSING (make)



LOCKING, CIRCUIT OPENING (break)

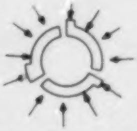


TRANSFER, 3-POSITION

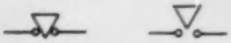


WAFER

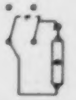
(example shown: 3-pole 3-circuit with 2 nonshorting and 1 shorting moving contacts)



SAFETY INTERLOCK, CIRCUIT OPENING AND CLOSING

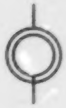


2-POLE FIELD-DISCHARGE KNIFE, WITH TERMINALS AND DISCHARGE RESISTOR



(identification replaces (*) asterisk)

SYNCHRO (78)

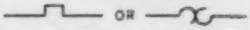


SYNCHRO LETTER COMBINATIONS

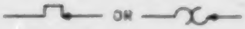
CDX	CONTROL-DIFFERENTIAL TRANSMITTER
CT	CONTROL TRANSFORMER
CX	CONTROL TRANSMITTER
TDR	TORQUE-DIFFERENTIAL RECEIVER
TDX	TORQUE-DIFFERENTIAL TRANSMITTER
TR	TORQUE RECEIVER
TX	TORQUE TRANSMITTER
RS	RESOLVER
B	OUTER WINDING ROTATABLE IN BEARINGS

THERMAL ELEMENT (83)

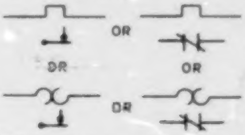
ACTUATING DEVICE



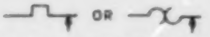
THERMAL CUTOUT; FLASHER



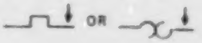
THERMAL RELAY



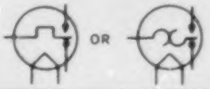
THERMOSTAT (operates on rising temperature), CONTACT



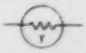
THERMOSTAT, MAKE CONTACT



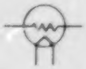
THERMOSTAT, INTEGRAL HEATER AND TRANSFER CONTACTS



THERMISTOR, THERMAL RESISTOR (84)

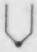


WITH INTEGRAL HEATER

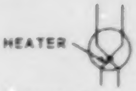


THERMOCOUPLE (85)

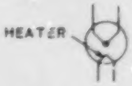
TEMPERATURE-MEASURING



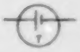
CURRENT-MEASURING, INTEGRAL HEATER CONNECTED



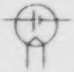
CURRENT-MEASURING, INTEGRAL HEATER INSULATED



TEMPERATURE-MEASURING, SEMICONDUCTOR

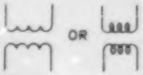


CURRENT-MEASURING, SEMICONDUCTOR

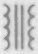


TRANSFORMER (86)

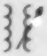
GENERAL



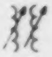
MAGNETIC-CORE



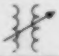
ONE WINDING WITH ADJUSTABLE INDUCTANCE



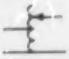
SEPARATELY ADJUSTABLE INDUCTANCE



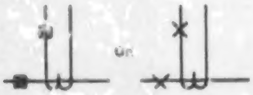
ADJUSTABLE MUTUAL INDUCTOR, CONSTANT-CURRENT



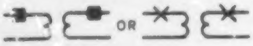
AUTOTRANSFORMER, 1-PHASE ADJUSTABLE



CURRENT, WITH POLARITY MARKING

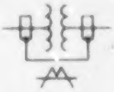


POTENTIAL, WITH POLARITY MARK

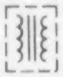


WITH DIRECT-CURRENT CONNECTIONS AND MODE SUPPRESSION BETWEEN TWO RECTANGULAR WAVEGUIDES

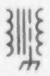
(common coaxial/waveguide usage)



SHIELDED, WITH MAGNETIC CORE

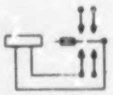


WITH A SHIELD BETWEEN WINDINGS, CONNECTED TO THE FRAME

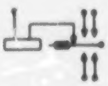


VIBRATOR, INTERRUPTER (57)

TYPICAL SHUNT DRIVE (terminals shown)

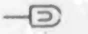


TYPICAL SEPARATE DRIVE (terminals shown)

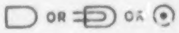


VISUAL SIGNALING DEVICE (58)

COMMUNICATION SWITCHBOARD-TYPE LAMP



INDICATING, PILOT, SIGNALING, OR SWITCHBOARD LIGHT (see LAMP)



(identification replaces (*) asterisk)

INDICATING LIGHT-LETTER COMBINATIONS

A	AMBER
B	BLUE
C	CLEAR
G	GREEN
NE	NEON
O	ORANGE
OP	OPALESCENT
P	PURPLE
R	RED
W	WHITE
Y	YELLOW

JEWELED SIGNAL LIGHT

13.5G

APPENDIX III

BASIC ELECTRICAL FORMULAS

Ohm's Law for D-C Circuits

$$I = \frac{E}{R} = \frac{P}{E} = \sqrt{\frac{P}{R}}$$

$$R = \frac{E}{I} = \frac{P}{I^2} = \frac{E^2}{P}$$

$$E = IR = \frac{P}{I} = \sqrt{PR}$$

$$P = EI = \frac{E^2}{R} = I^2 R$$

Resistors in Series

$$R_T = R_1 + R_2 + \ldots$$

Resistors in Parallel

Two resistors

$$R_T = \frac{R_1 R_2}{R_1 + R_2}$$

More than two

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

RL Circuit Time Constant

$\frac{\text{L (in henrys)}}{\text{R (in ohms)}}$ = t (in seconds), or

$\frac{\text{L (in microhenrys)}}{\text{R (in ohms)}}$ = t (in microseconds)

RC Circuit Time Constant

R (ohms) x C (farads) = t (seconds)

R (megohms) x C (microfarads) = t (seconds)

R (ohms) x C (microfarads) = t (microseconds)

R (megohms) x C (micromicrofarads) = t (microseconds)

Capacitors in Series

Two capacitors

$$C_T = \frac{C_1 C_2}{C_1 + C_2}$$

More than two

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$$

Capacitors in Parallel: $C_T = C_1 + C_2 + \ldots$

Capacitive Reactance: $X_C = \frac{1}{2\pi fC}$

Impedance in an RC Circuit (Series)

$$Z = \sqrt{R^2 + (X_C)^2}$$

Inductors in Series

$L_T = L_1 + L_2 + \ldots$ (No coupling between coils)

Inductors in Parallel

Two inductors

$L_T = \frac{L_1 L_2}{L_1 + L_2}$ (No coupling between coils)

More than two

$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots$ (No coupling between coils)

Inductive Reactance

$$X_L = 2\pi fL$$

Q of a Coil

$$Q = \frac{X_L}{R}$$

INDEX

A

Abstracting, commercial, 363-374

A. C. generator, basic, 40-50

Advancement and training, 1-13

Alternating current, introduction to, 40-59

Amplitude-modulated (AM) transmitter, 64-71
  AM spectrum and bandwidth, 67
  modulation, 64-67
  percent of modulation, 69-71
  spectrum for multiple-modulation, 68
Antenna field strength measurements, 172
Antenna theory, basic, 88-99
  antenna characteristics, 90-96
    antenna feed point, 91
    antenna tuning, 90
    characteristic impedance, 91
    directivity, 94
    field intensity, 95
    frequency and impedance, 92
    incident and reflected waves, 96
    radiation resistance, 96
    wavelength, 92
    wave polarization, 93
  basic antenna circuit, 89
  half-wave theory, 96-98
  quarter-wave theory, 98-99
  terms and definitions, 88

Automated systems, 293-322
  AUTODIN, 293-313
    AUTODIN data pattern messages, 306-311
    AUTODIN security, 313
    AUTODIN switching centers, 293-295
    AUTODIN teletypewriter, 300-306
    digital subscriber terminal equipment, 295-300
    magnetic tape messages, 311-313

  AUTOSEVOCOM, 316-319
    definitions, 317
    general operating procedures, 317
    security requirements, 319

Automated systems—Continued
  AUTOVON, 313-316
    classes of telephone service, 314
    general user information, 316
    precedence of calls, 314
    term definitions, 313
    types of service, 315
  other systems, 319-322
    local digital message exchange, 319
    message processing and distribution system, 319
    naval communications processing and routing system, 321
    satellite information exchange system, 322

B

Basic communication center files, 195
Basic electricity, 14-59
Basic message format, 215-247
Basic transmitter theory, 60-77

C

Capacitance, 54-58
Circuit discipline and security, 248-249
Circuit procedures, 258-270
Circuit, simple electric, 19-23
Clerk, commercial traffic, 357
Code and cipher messages, 272
Commercial traffic, 357-377
  coastal harbor radiotelephone service, 374-376
    arrangements with telephone company for initiation of service, 374
  commercial abstracting, 363-374
    Class A and Class B messages, 363-365
    Class D messages, 365-368
    Class D messages entitled to Class E privilege, 368
    Class E messages, 371-374

399

- Commercial traffic—Continued
    - commercial abstracting—Continued
    - press messages, 369-371
    - radiophotos, 371
  - commercial traffic clerk, 357
  - commercial traffic funds, 358
    - refunds, 358
    - uses of, 358
  - commercial traffic reports, 358-363
    - report symbols, 363
    - responsibility for reports, 361
    - serial numbers, 361
    - word count systems, 363
  - high seas radiotelephone service, 376-377
    - conditions under which service is furnished, 376-377
- Communications distress, 350-356
- Communications, fleet, 323-349
- Communications organization, 182-197
  - basic communication center files, 195
  - command ship communications, 189
  - communications materiel support, 189
  - communication training requirements, 196-197
  - DCA control complex, 184
  - defense communications system, 183
  - disposal of files and logs, 196
  - maintenance data collection system, 190
  - naval communication areas, 184
  - naval telecommunications system, 182-183
  - Naval Warfare Publications Library, 191-195
  - operation orders, 189
  - repair part support, 190
  - shipboard communication organization, 187
  - shipboard operational organization, 188
  - shore communications departments, 184-178
- Communications security, 198-214
  - authentication, 212
  - communication center visitor's log, 213
  - COMSEC destruction, 210
  - CRYPTO, 209
  - custodians of classified material, 204-206
  - danger of espionage, 198
  - declassification schedule, general, 201-202
  - destruction of classified material, 206
  - EFTO and FOUO, 200
  - emission control, 211
  - handling and stowage of classified material, 204
  - LIMDIS, 200
  - meaconing, interference, jamming, and intrusion, 211
  - national security agency, 213
  - naval security groups, 212
  - NOFORN, 200
  - personal security censorship, 213-214
- Communications security—Continued
  - security areas, 203
  - security classification categories, 199-200
    - Confidential, 200
    - Secret, 200
    - Top Secret, 199
  - security control and responsibility, 199
  - security versus speed, 212
  - SPECAT, 201
  - special markings, 200
- Communications transmitter testing, 159-162
- Communication system, basic, 60
- Computer equipment testing, 176
- Computer quality assurance techniques, 177-180
- Conductance, 22
- Conductors and insulators, 16-17
- Continuous-wave (CW) transmitter, 61-64
  - buffer, 63
  - oscillator, 62
  - power-amplifier, 63
  - power supply, 63-64
- Current, 20-21

D

- DCA control complex, 184
- Declassification schedule, general, 201
- Defense communications system, 183
- Diagnosis and assurance logic, 180-181
- Direct current, introduction to, 23-40
- Distress communications, 350-356
  - distress frequencies, 350
  - distress watches afloat, 351-354
    - acknowledging receipt, 352
    - cessation of distress traffic, 352
    - follow-up messages, 352
    - methods of transmission, 352
  - distress watches ashore, 356
  - merchant ship distress, 355
  - safety signal, 354
  - urgency signal, 354
    - procedures, 354

E

- Electrical Formulas, Basic, Appendix III, 391
- Electrical safety precautions, 140-145
- Electricity, basic, 14-59
  - introduction to alternating current (a.c.), 40-59
    - basic a.c. generator, 40-50
    - capacitance, 54-58
    - inductance, 50-53
    - inductive and capacitive reactance, 58-59
    - inductive voltage and current, 53

- Electricity, basic—Continued
  - introduction to direct current, 23-40
    - commonly used electronic terms, 29-32
    - parallel d.c. circuits, 32-38
    - series d.c. circuits, 24-29
    - series-parallel combinations, 38-40
  - simple electric circuit, 18-23
    - conductance, 22
    - current, 20-21
    - power, 22
    - resistance, 22
    - voltage, 19
  - what is electricity, 14-17
    - basic particles of matter, 14-16
    - conductors and insulators, 16-17
- Emission control, 211
- Enemy contact reporting, 272
- Espionage, danger of, 198
- Examination procedures, 10-13
  - taking the exam, 10-13
    - profile analysis form, 12-13
    - Subject-Matter Identification Sheet, 12

F

- Fading, 112
- Fleet communications, 323-349
  - fleet multichannel broadcast system ("N" System), 323-327
    - broadcast control, 323
    - broadcast file, 326
    - broadcast identification, 324
    - broadcast operation, 325
    - broadcast shifts, 326
  - fleet satellite communications, 347-349
  - other broadcasts, 327-330
    - single channel broadcast 327-330
  - ship/shore and ship/ship circuits, 330-342
    - autocat and middleman operation, 336
    - Fleet Flash Net, 338
    - Fleet Warning/Tactical UHF Net, 340
    - full duplex FSK ship/shore/ship (RFCS), 332-336
    - full period terminations, 340-342
    - Interim Command Switchboard, 338
    - Navy High Command World-Wide Voice Network, 339
    - Pigeon Post, 338
    - secondary ship/shore circuits, 336
    - ship/shore network, 330-332
    - UHF/HF relay, 337
  - radio emission designators, 342-344
    - bandwidth, 343
    - modulation of the main carrier, types of, 343
    - supplementary characteristics, 344
    - transmission, types of, 344
- Fleet communications—Continued
  - transmitter and receiver tuning, 344-347
    - transmitter testing, 344
- Frequency bands and characteristics, 113-115
- Frequency generators, 132-135
- Frequency measurement, 129
- Frequency modulation, 74-77
  - FM bandwidth, 75-76
  - FM sideband, 75
  - modulation index, 76
  - percent of modulation, 77
- Frequency standards, 130-132
- Funds, commercial traffic, 358

G

- Glossary of terms, Appendix I, 378-383

I

- Inductance, 50-53
- Ionospheric propagation, basic, 110-112

M

- Machine functions, 274-275
- Maintenance data collection system, 190
- Manuals, training, 9-10
- Manual teletypewriter procedures, 274-292
- Matter, basic particles of, 14-16
  - atom, 15
  - ionization, 16
  - molecule, 15
- Mechanical and electrical symbols, 384-390
- Merchant ship distress, 355
- Message alignment, 275
- Message format, basic, 215-247, 250-258
  - addressees, 223-225
  - address groups, 226
  - call signs, 225
  - cancelling messages, 229
  - classes of messages, 223
  - ending, 221
  - heading, 215-218
    - address component, 217
    - beginning procedure, 215-217
    - preamble component, 217
    - prefix component, 218
    - separation, 218
  - message categories, 231-237
  - message user responsibilities, 221
  - operating signals, 230
  - optical character reader, Message Form DD 173, 237-247
    - constructing the address, 242
    - constructing the text, 242-245

- Message format, basic—Continued
  - optical character reader, Message Form DD 173—Continued
    - general instructions, 237-239
    - headerlines, 239-242
    - message readdressals, 245-247
  - plain language address directory, 227
  - prosigns, 229
  - readdressing a message, 228
  - text, 218-220
    - classification line, 218
    - indenting, 220
    - passing instructions, 220
    - punctuation, 220
    - reference line(s), 220
    - restricted data paragraph markings, 220
    - special handling markings, 219
    - subject line, 220
- Message format, teletype, 276
- Message punctuation, 276
- Meters, types of, 119

N

- Naval Warfare Publications Library, 191-195

O

- Operator maintenance, types of, 146
- Optical character reader, Message Form DD173, 237-247
- Oscilloscopes, 135-137

P

- Parallel d.c. circuits, 32-38
- Power, 22
- Propagation, radio wave, 100-115

Q

- Quality assurance and system diagnosis, 146-181

R

- Radio emission designators, 342-344
- Radioman rating, 1-9
- Radiotelephone procedures, 248-273
  - authentication, 271
  - basic message format, 250-258
    - format lines 1, 2, 3, and 4, 250
    - format line 5, 256
    - format lines 6, 7, 8, and 9, 256
    - format line 10, 256
    - format lines 11 through 16, 256-258
- Radiotelephone procedures—Continued
  - circuit discipline and security, 248-249
    - importance of radiotelephone, 249
    - radiotelephone security, 248
  - circuit procedures, 258-270
    - acknowledgement of R/T messages, 269
    - break-in procedure, 269
    - cancelling messages, 268
    - code and cipher messages, 272
    - corrections, 267
    - decimals, dates, and abbreviations, 263
    - emergency silence, 270
    - establishing communications, 264-267
    - local harbor circuits, 258
    - opening the net, 259
    - phonetic alphabet, 261
    - pronunciation of numerals, 262
    - punctuation, 263
    - radiotelephone call signs, 264
    - receipt of a message, 268
    - repetitions, 267-268
    - R/T circuit logs, 261
    - types of nets, 259
    - use of operating signals, 263
    - use of prowords, 264
    - verifying an R/T message, 269
    - voice communication requirements, 258
  - enemy contact reporting, 272
  - executive method for R/T, 270
    - delayed executive method, 271
    - immediate executive method, 271
  - operational brevity code, 272
  - security consciousness, 272
- Radiotelephone service, coastal harbor, 374-376
- Radiotelephone service, high seas, 376-377
- Radio wave propagation, 100-115
  - basic ionospheric propagation, 110-112
    - absorption in the ionosphere, 112
    - effect of ionosphere on the sky wave, 111
    - periodic variations, 112
    - variations in the ionosphere, 112
  - basic tropospheric propagation, 107-110
    - forward propagation tropospheric scatter communications, 107-110
    - tropospheric wave, 107
  - composition of the earth's atmosphere, 104
  - differaction, reflection and refraction, 101-104
  - fading, 112
  - frequency bands and characteristics, 113-115
  - terms and definitions, 100-101
  - types of radio wave propagation, 105-107
    - sky wave, 106
    - space wave, 106
    - surface wave, 105
- Receiver quality assurance, 154-159

- Receiver theory, basic, 78-87
  - receiver functions, 78
  - receiver input, origin of, 78
  - superheterodyne receiver, 79-87
    - receiver control circuits, 84
- Receiver tuning and transmitter, 344-347
- Repair part support, 190
- Reports, commercial traffic, 358-363
- Resistance, 22

S

- Safety signal, 354
- Security, communications, 198-214
- Shipboard communication organization, 187
- Shipboard operational organization, 188
- Ship/shore and ship/shore circuits, 330-342
- Shore communications departments, 184-187
- Single-sideband (SSB) transmitter, 71-74
  - functional SSB transmitter, 72
  - single-sideband, 72
  - SSB receivers, 73-74
- Spectrum analysis, 137-140
- Superheterodyne receiver, 79-87
  - AF amplifier, 84
  - antenna section, 80
  - automatic frequency control, 87
  - automatic gain control, 85
  - beat-frequency (BFO), 86
  - delayed automatic gain control, 86
  - detector, 84
  - IF amplifier, 83
  - manual gain control (MGC), 84
  - mixer and local oscillator, 83
  - receiver control circuits, 84
  - RF amplifier, 81-83
  - silencer, 87
- System diagnosis and quality assurance, 146-181
  - antenna field strength measurements, 172
  - basic measurements, 147-149
    - oscilloscope measurements, 148
    - resistive measurements, 148
    - voltage measurements, 148
  - communications transmitter testing, 159-162
    - frequency measurements, 160
    - output power measurements, 160
    - transmitter neutralization, 161
  - computer equipment testing, 176-177
    - analog computers, 176
    - arithmetic, 177
    - computer types, 176
    - control, 177
    - digital computers, 177
    - input, 177
    - memory, 177
    - output, 177
- System diagnosis and quality assurance—Continued
  - computer quality assurance techniques, 177-180
    - add instruction, 179
    - basic programs, 178
    - clear and add instruction, 179
    - diagnostic programs, 179
    - full store instruction, 180
    - halt instructions, 179
    - maintenance programs, 178
    - reliability programs, 178
  - diagnosis and assurance logic, 180-181
    - evaluation of equipment performance, 180
    - recording data, 181
    - use of functional block diagrams, 181
    - use of operating controls, 180
  - mutual interference problems, 170-172
    - antenna location, 170
    - cross modulation, 171
    - receiver-to-receiver interference, 171
    - reduction to transmitter radiation, 172
    - spurious transmitter radiation, 171
    - transmitter-to-receiver interference, 170
  - operator maintenance, types of, 146
  - performance testing measurements, 149-154
    - electron tube testing, 153
    - frequency spectrum measurements, 152
    - impedance testing of antennas and transmission lines, 153
    - power output measurements, 152
    - receiver gain measurements, 151
    - receiver noise measurements, 149
    - receiver sensitivity measurements, 151
  - receiver quality assurance, 154-159
    - assurance diagnosis and the decibel, 154
    - cross-modulation test, 157
    - CW and facsimile sensitivity checks, 155
    - FSK sensitivity determination, 156
    - receiver response curves, 156
    - receiver selectivity and bandwidth measurements, 157
    - reserve gain determination, 156
    - single sideband sensitivity measurements, 155
    - squelch (silencer) circuit measurements, 158
    - tuning dial calibration, 159
    - voice modulated sensitivity checks, 156
    - warm-up frequency drift, 159
  - single sideband testing, 173-176
    - balanced modulator adjustments, 173
    - peak envelope power measurement, 175
    - RF carrier oscillator, 173
    - sideband filters, 174
    - SSB receiver maintenance techniques, 176

- System diagnosis and quality assurance—Continued
  - single sideband testing—Continued
    - SSB signal-to-noise measurements, 175
    - SSB transmitter monitoring, 176
    - two-tone testing in SSB, 174
  - systems test, types of, 146
  - teletype systems testing, 162-165
    - basic keyboard and tape transmitter tests, 165
    - range selection, 165
    - teletypewriter operational speeds, 163
    - teletypewriter signals, 163
    - types of transmissions, 163-165
  - teletypewriter distortion, 165-170
    - causes and effects of bias distortion, 166
    - causes and effects of characteristic distortion, 168
    - causes and effects of fortuitous distortion, 168
    - causes and effects of speed problems, 169
    - multiplex and crypto distortion, 169
- Systems, automated, 293-322

T

- Telecommunications system, naval, 182-183

- Teletype systems testing, 162-165

- Teletypewriter distortion, 165-170

- Teletypewriter procedures, manual, 274-292
  - basic operating instructions, 279-292
    - cancellations, 284
    - corrections, 282
    - counting and checking groups, 284-286
    - manual switching systems, 291-292
    - manual TTY calling and answering, 279-282
    - transmission of messages, 286-287
    - use of common prosigns, 288-291
  - machine functions, 274-275
    - bell signal, 275
    - blank, 275
    - carriage return, 275
    - line feed, 275
    - margin bell, 275
    - shift, 274
    - space, 274
    - warning light, 275
  - message alignment, 275
  - message punctuation, 276
  - teletype message format, 276
- Test equipment, basic, 116-145
  - basic requirements of test equipment, 118
  - calibration of test equipment, 118
  - care, use, and handling of test equipment, 116
  - commonly used test equipment, 120-129
    - ammeters, 120-123
    - megohmmeter (megger), 126-129
    - ohmmeters, 124-126
    - voltmeters, 123
  - electrical safety precautions, 140-145
    - cathode-ray tubes, 143
    - fire precautions, 143-145
    - general safety practices, 140
    - rescue of shock victims, 142
    - RF-energy burns, 143
    - safety shorting probe, 141
    - symptoms of electrical shock, 141
  - electron tube testers, 137-140
    - emission testers, 138-140
    - transconductance testers, 140
  - frequency generators, 132-135
    - audio, 132-134
    - radio, 134
  - frequency measurement, 129
    - heterodyne frequency meters, 129
  - frequency standards, 130-132
    - audio frequencies and musical pitch, 131
    - radio frequencies, 131
    - radio propagation forecasts, 131
    - secondary standards, 132
    - silent periods, 132
    - time intervals and signals, 131
    - U.S. National Bureau of Standards, 131
  - oscilloscopes, 135-137
    - graticules, 137
    - personnel safety precautions, 137
    - power supplies, 136
    - screen, 135
  - selection of test equipment, 117-118
    - amplitude, 118
    - frequency, 117
    - impedance matching, 117
    - polarity, 118
  - spectrum analysis, 137
  - types of meters, 119
- Testing measurements, performance, 149-154
- Traffic, commercial, 357-377
- Training and advancement, 1-13
  - examination procedures, 10-13
  - Radioman rating, 1-9
    - factors which affect advancement, 3
    - how to prepare for advancement, 6-9
    - how to qualify for advancement, 2
    - military duties, 1
    - Navy advancement system, 2
    - taking the exam, 10-13

Training and advancement—Continued
  training manuals, 9-10
    basic Navy training manuals, 9
    nonresident career courses, 10
    rate training manuals, 9
Transmitter theory, basic, 60-77
  basic communication system, 60
  types of transmitters, 61-77
    amplitude-modulated (AM) transmitter, 64-71
    continuous-wave (CW) transmitter, 61-64
    frequency modulation, 74-77
    single-sideband (SSB) transmitter, 71-74
    transmitter troubleshooting, 77
Tropospheric propagation, basic, 107-110

U

Urgency signal, 354

V

Voltage, 19

W

Watch afloat, distress, 351-354
Watches ashore, distress, 356

RADIOMAN 3 & 2

NAVEDTRA 10228-G

Prepared by the Naval Education and Training Program Development
Center, Pensacola, Florida

Your NRCC contains a set of assignments and self-scoring answer sheets (packaged separately). The Rate Training Manual, Radioman 3&2, NAVEDTRA 10228-G , is your textbook for the NRCC. If an errata sheet comes with the NRCC, make all indicated changes or corrections. Do not change or correct the textbook or assignments in any other way.

HOW TO COMPLETE THIS COURSE SUCCESSFULLY

Study the textbook pages given at the beginning of each assignment before trying to answer the items. Pay attention to tables and illustrations as they contain a lot of information. Making your own drawings can help you understand the subject matter. Also, read the learning objectives that precede the sets of items. The learning objectives and items are based on the subject matter or study material in the textbook. The objectives tell you what you should be able to do by studying assigned textual material and answering the items.

At this point you should be ready to answer the items in the assignment. Read each item carefully. Select the BEST ANSWER for each item, consulting your textbook when necessary. Be sure to select the BEST ANSWER from the subject matter in the textbook. You may discuss difficult points in the course with others. However, the answer you select must be your own. Use only the self-scoring answer sheet designated for your assignment. Follow the scoring directions given on the answer sheet itself and elsewhere in this course.

Your NRCC will be administered by your command or, in the case of small commands, by the Naval Education and Training Program Development Center. No matter who administers your course you can complete it successfully by earning grades that average 3.2 or higher. If you are on active duty, the average of your grades in all assignments must be at least 3.2. If you are NOT on active duty, the average of your grades in all assignments of each creditable unit must be at least 3.2. The unit breakdown of the course, if any, is shown later under Naval Reserve Retirement Credit.

WHEN YOUR COURSE IS ADMINISTERED BY LOCAL COMMAND

As soon as you have finished an assignment, submit the completed self-scoring answer sheet to the officer designated to administer it. He will check the accuracy of your score and discuss with you the items that you do not understand. You may wish to record your score on the assignment itself since the self-scoring answer sheet is not returned.

If you are completing this NRCC to become eligible to take the fleetwide advancement examination, follow a schedule that will enable you to complete all assignments in time. Your schedule should call for the completion of at least one assignment per month.

Although you complete the course successfully, the Naval Education and Training Program Development Center will not issue you a letter of satisfactory completion. Your command will make a note in your service record, giving you credit for your work.

WHEN YOUR COURSE IS ADMINISTERED BY THE NAVAL EDUCATION AND TRAINING PROGRAM DEVELOPMENT CENTER

After finishing an assignment, go on to the next. Retain each completed self-scoring answer sheet until you finish all the assignments in a unit (or in the course if it is not divided into units). Using the envelopes provided, mail your self-scored answer sheets to the Naval Education and Training Program Development Center where the scores will be verified and recorded. Make sure all blanks at the top of each answer sheet are filled in. Unless you furnish all the information required, it will be impossible to give you credit for your work. You may wish to record your scores on the assignments since the self-scoring answer sheets are not returned.

The Naval Education and Training Program Development Center will issue a letter of satisfactory completion to certify successful completion of the course (or a creditable unit of the course). To receive a course-completion letter, follow the directions given on the course-completion form in the back of this NRCC.

You may keep the textbook and assignments for this course. Return them only in the event you disenroll from the course or otherwise fail to complete the course. Directions for returning the textbook and assignments are given on the book-return form in the back of this NRCC.

PREPARING FOR YOUR ADVANCEMENT EXAMINATION

Your examination for advancement is based on the Manual of Navy Enlisted Manpower and Personnel Classification and Occupational Standards (NAVPERS 18068-D). The sources of questions in this examination are given in the Bibliography for Advancement Study (NAVEDTRA 10052). Since your NRCC and textbook are among the sources listed in this bibliography, be sure to study both in preparing to take your advancement examination. The standards for your rating may have changed since your course and textbook were printed, so refer to the latest editions of NAVPERS 18068-D and NAVEDTRA 10052.

NAVAL RESERVE RETIREMENT CREDIT

This course is evaluated at 23 Naval Reserve retirement points and will be credited in units as follows: Unit 1: 12 points upon completion of Assignments 1 through 8; Unit 2: 11 points upon completion of Assignments 9 through 15. These points are creditable to personnel eligible to receive them under current directives governing the retirement of Naval Reserve personnel. Naval Reserve retirement credit will not be given if the student has previously received credit for any Radioman 3 & 2, NRCC or ECC.

COURSE OBJECTIVE

While completing this NRCC, you will demonstrate a knowledge of course material by correctly answering items on the following: organization of the enlisted rating structure and career opportunities available to enlisted personnel; basic electricity and electronics; basic transmitter and receiver theory; basic principles and common configurations of communications antennas; types and theory of radio wave propagation; basic test equipment; systems of diagnosis and quality assurance; communication organization; procedures involved in the security and handling of classified information; basic message format, fleet communications, and automated systems; theory and operation of basic teletypewriter circuits and associated radio communications equipment; radiotelephone procedures and distress communications; and classes, types, and handling of commercial traffic.

While working on this nonresident career course, you may refer freely to the text. You may seek advice and instruction from others on problems arising in the course, but the solutions submitted must be the result of your own work and decisions. You are prohibited from referring to or copying the solutions of others, or giving completed solutions to anyone else taking the same course.

Naval correspondence courses may include a variety of items -- multiple-choice, true-false, matching, etc. The items are not grouped by type; regardless of type, they are presented in the same general sequence as the textbook material upon which they are based. This presentation is designed to preserve continuity of thought, permitting step-by-step development of ideas. Some courses use many types of items, others only a few. The student can readily identify the type of each item (and the action required of him) through inspection of the samples given below.

MULTIPLE-CHOICE ITEMS

Each item contains several alternatives, one of which provides the best answer to the item. Select the best alternative and erase the appropriate box on the answer sheet.

SAMPLE

s-1. The first person to be appointed Secretary of Defense under the National Security Act of 1947 was
1. George Marshall
2. James Forrestal
3. Chester Nimitz
4. William Halsey

The erasure of a correct answer is indicated in this way on the answer sheet:

	1 T	2 F	3	4
s-1	■	C	■	■

TRUE-FALSE ITEMS

Determine if the statement is true or false. If any part of the statement is false the statement is to be considered false. Erase the appropriate box on the answer sheet as indicated below.

SAMPLE

s-2. Any naval officer is authorized to correspond officially with a bureau of the Navy Department without his commanding officer's endorsement.

The erasure of a correct answer is also indicated in this way on the answer sheet:

	1 T	2 F	3	4	
s-2	■	CC	■	■	

MATCHING ITEMS

Each set of items consists of two columns, each listing words, phrases or sentences. The task is to select the item in column B which is the best match for the item in column A that is being considered. Specific instructions are given with each set of items. Select the numbers identifying the answers and erase the appropriate boxes on the answer sheet.

SAMPLE

In items s-3 through s-6, match the name of the shipboard officer in column A by selecting from column B the name of the department in which the officer functions.

A. Officers	B. Departments
s-3. Damage Control Assistant	1. Operations Department
s-4. CIC Officer	2. Engineering Department
s-5. Assistant for Disbursing	3. Supply Department
s-6. Communications Officer	

The erasure of a correct answer is indicated in this way on the answer sheet:

	1 T	2 F	3	4	
s-3	■	C	■	■	
s-4	C	■	■	■	
s-5	■	■	C	■	
s-6	C	■	■	■	

How To Score Your Immediate Knowledge of Results (IKOR) Answer Sheets

	1 T	2 F	3	4	
1	■	C	6	■	1
2	C	9	■	9	2
3	■	■	C	■	
4	CC	12	■	■	1

Total the number of incorrect erasures (those that show page numbers) for each item and place in the blank space at the end of each item.

Sample only

Number of boxes erased incorrectly	0-2	3-7	8-
Your score	4.0	[✓ 3.9]	3.8

Now TOTAL the column(s) of incorrect erasures and find your score in the Table at the bottom of EACH answer sheet.

NOTICE: If, on erasing, a page number appears, review text (starting on that page) and erase again until "C", "CC", or "CCC" appears. For courses administered by the Center, the maximum number of points (or incorrect erasures) will be deducted from each item which does NOT have a "C", "CC", or "CCC" uncovered (i.e., 3 pts. for four choice items, 2 pts. for three choice items, and 1 pt. for T/F items).

Assignment 1

Training and Advancement; Basic Electricity

Textbook Assignment: Pages 1 - 59

In this course you will demonstrate that learning has taken place by correctly answering training questions. The mere physical act of indicating a choice on an answer sheet is not in itself important; it is the mental achievement, in whatever form it may take, prior to the physical act that is important and toward which nonresident career course learning objectives are directed. The selection of the correct choice for a course training question indicates that you have fulfilled, at least in part, the stated objective(s).

The accomplishment of certain objectives, for example, a physical act such as drafting a memo, cannot readily be determined by means of objective type course questions; however, you can demonstrate by means of answers to training questions that you have acquired the requisite knowledge to perform the physical act. The accomplishment of certain other learning objectives, for example, the mental acts of comparing, recognizing, evaluating, choosing, selecting, etc., may be readily demonstrated in a course by indicating the correct answers to training questions.

The comprehensive objective for this course has already been given. It states the purpose of the course in terms of what you will be able to do as you complete the course.

The detailed objectives in each assignment state what you should accomplish as you progress through the course. They may appear singly or in clusters of closely related objectives, as appropriate; they are followed by questions which will enable you to indicate your accomplishment.

All objectives in this course are learning objectives and questions are teaching questions. They point out important things, they assist in learning, and they should enable you to do a better job for the Navy.

This self-study course is only one part of the total Navy training program; by its very nature it can take you only part of the way to a training goal. Practical experience, schools, selected reading, and the desire to accomplish are also necessary to round out a fully meaningful training program.

Learning Objective: Identify the publications containing specified information which relates to training and advancement, state ways in which personnel may prepare for advancement, and briefly explain the method of selection for advancement.

1-1. What document contains a list of the basic occupational skills required by your rating?
   1. The Occupational Standards Manual, NAVPERS 18068
   2. Personnel Qualifications Standards Manual
   3. Occupational Analysis List
   4. Manual for Advancement

1-2. If you are an E-4 preparing to advance to E-5, you should expect your advancement exam to question the minimum skills for
   1. E-5 only
   2. E-4 and E-5 only
   3. E-3, E-4, and E-5
   4. E-4, E-5, and E-6

1-3. In what publication(s) can you find the list of reading material you should study for advancement?
   1. NAVEDTRA 10052
   2. Occupational Standards and Bibliography Sheet
   3. Both 1 and 2 above
   4. NAVEDTRA 10054

A. PERFORMANCE MARKS
B. TIME IN PAYGRADE/LENGTH OF SERVICE
C. PERFORMANCE TEST
D. MILITARY LEADERSHIP EXAM SCORE
E. ADVANCEMENT EXAM SCORE
F. REQUIRED COURSES/SCHOOLS
G. PARS
H. AWARDS
I. PNA POINTS

List 1A

- In answering question 1-4, refer to list 1A.

1-4. Which entries are reflected in the final multiple?
1. A, B, D, E, G, and H
2. B, D, E, H, and I
3. A, B, E, H, and I
4. A, B, C, E, F, and I

1-5. What is the purpose of the PQS program?
1. To replace rate training manuals and nonresident career courses
2. To provide a checkoff list of task statements pertaining to the trainee's military ability
3. To replace the Personnel Advancement Requirement program
4. To assist in qualifying the trainee to perform assigned duties

1-6. Some rate training manuals listed in NAVEDTRA 10052 are marked with an asterisk (*). In the advancement system they are
1. obsolete
2. mandatory
3. not required
4. new

1-7. What publication lists the latest editions of the rate training manuals and correspondence courses for your rating?
1. Bibliography for Advancement Study, NAVEDTRA 10052
2. List of Training Manuals and Correspondence Courses, NAVEDTRA 10061
3. Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards. NAVPERS 18068D
4. Personnel Advancement Requirement (PAR), NAVPERS 1414/4

1-8. How often is the NAVEDTRA 10061 revised and issued?
1. Semiannually
2. Quarterly
3. Annually
4. Monthly

1-9. Which of the following are rate training manuals (RTMs) and nonresident career courses (NRCCs) intended to be?
1. Technical manuals
2. Trainee guides
3. Instructor guides
4. Self-study packages

1-10. Which of the following study habits should you follow while studying a rate training manual?
1. Try to cover a complete unit
2. Write down questions that occur to you
3. Relate information in the manual to knowledge you already have
4. All of the above

1-11. Who writes the examination for advancement to PO3, PO2, or PO1?
1. An education specialist holding a college degree in testing
2. A training specialist who is a licensed craftsman
3. A subject matter expert enrolled in the graduate school of a major university
4. A senior CPO who is an expert in the particular rating

1-12. What should you do with the Recommendation Sheet that the Educational Services Officer gives you before the day of your advancement examination?
1. Examine the sheet to make sure that the information on it is correct
2. See that it becomes a part of your jacket
3. Get your commanding officer to initial the sheet
4. Mail it to NETPDC

1-13. You can use the Subject Matter Section Identification Sheet from your examination booklet to help analyze your performance on the examination itself. To do so, you must compare the
1. examination score with the minimum multiple required for advancement
2. examination status with your final multiple as given on the profile analysis form
3. results of the examination with the information given in sections 1 through 12 of the profile analysis form

1-14. The information shown in sections 1 through 12 of the profile analysis form enables you to
1. compare your final multiple with the multiples of those who passed the same examination
2. compare your examination performance with that of others who took the same examination
3. determine the number of points given for passing the examination but not being advanced

1-15. Although information concerning your career and advancement may be obtained from many sources, the best source is your
1. Educational Services Officer
2. leading chief petty officer
3. supervisor
4. Navy buddies

Learning Objective: Explain why it is important for a Radioman to increase his knowledge of electricity.

1-16. Why is it important for you to expand your knowledge of the basic fundamentals of electricity as you work to advance in rate?
1. The Radioman rating encompasses a very broad area, and requires more diversified knowledge than many other ratings
2. As you advance, not only will a higher degree of leadership be expected of you, but also a higher level of professional knowledge and skill
3. As you expand the circle of equipments with which you have physical contact, a growing knowledge of basic equipment is increasingly important to the physical safety of yourself, others, and your equipment
4. All of the above

Learning Objective: Determine the electrical characteristics of subatomic particles.

1-17. What type electrical charge, if any, do the following subatomic particles have: (a) proton, (b) neutron, and (c) electron?
1. (a) None, (b) positive, (c) negative
2. (a) Negative, (b) none, (c) positive
3. (a) Positive, (b) none, (c) negative
4. (a) Positive, (b) negative, (c) none

1-18. What is the polarity of travel of a directed flow of electrons?
1. From positive to negative only
2. From negative to positive only
3. The entire circuit may be toward positive or negative, depending upon the hook-up of leads at the battery terminals
4. Various parts of the circuitry may be toward positive or toward negative, depending upon internal circuit wiring

Learning Objective: Define the basic electrical properties of current, power, resistance, and voltage.

To answer questions 1-19 through 1-22, select from column B the electrical property defined in column A.

	A. Definitions	B. Electrical Properties
1-19.	A flow of electrons (by displacement)	1. Current
		2. Power
1-20.	That property of a substance which impedes the flow of electrons	3. Resistance
		4. Voltage
1-21.	Electromotive force (emf) or electrical potential	
1-22.	The rate at which work is done	

Learning Objective: Identify, name, and give the properties of materials of different conductance levels.

1-23. What are the most important characteristics of atoms comprising (a) good conductors and (b) good insulators?
1. (a) The ability to release free electrons easily;
   (b) the ability to store an electric charge and release it upon demand
2. (a) The ability to release electrons easily;
   (b) the ability to retain their electrons unless large amounts of energy or force are applied
3. (a) The ability to store an electric charge and release it upon demand;
   (b) the ability to retain their electrons unless large amounts of energy or force are applied
4. (a) The ability to block the flow of current effectively;
   (b) the ability to transmit current effectively

1-24. Some materials, such as germanium and silicon, are neither good conductors nor good insulators, but, rather, are in a category between. What is the name of this category?
1. Semiconductors
2. Parasitic conductors
3. Conduction simulators
4. Degenerate conductors

1-25. Other factors being equal, how does the resistance of a conductor vary in relation to (a) its length, and (b) its cross-sectional area?
1. (a) Directly, (b) inversely
2. (a) Inversely, (b) directly
3. (a) Directly, (b) directly
4. (a) Inversely, (b) inversely

Learning Objective: Compute the values of voltage, current, resistance, and power in a simple series circuit having a source of voltage and one resistor.

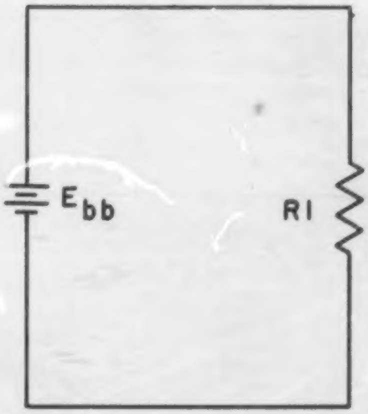


Figure 1A. - Simple series circuit.

● Refer to figure 1A in answering questions 1-26 through 1-30.

1-26. Assume resistance of 20 ohms and current of 3 amperes. Compute the voltage.
1. 0.15 V
2. 6.67 V
3. 23.0 V
4. 60.0 V

1-27. Assume resistance of 15 ohms and voltage of 60 volts. Compute the current.
1. 0.25 A
2. 4.0 A
3. 75.0 A
4. 900.0 A

1-28. Assume current of 5 amps and voltage of 30 volts. Compute the resistance.
1. 0.167 ohm
2. 6.0 ohms
3. 35.0 ohms
4. 150.0 ohms

1-29. Assume current of 3 amps and source voltage of 80 volts. Compute the power.
1. 0.004 W
2. 0.038 W
3. 26.667 W
4. 240.0 W

1-30. Assume source voltage of 60 volts and resistance of 5 ohms. Compute the power.
1. 0.2 W
2. 5.0 W
3. 300.0 W
4. 720.0 W

Learning Objective: Compute values of voltage, current, resistance, and power in a series circuit having a source of voltage and multiple resistors.

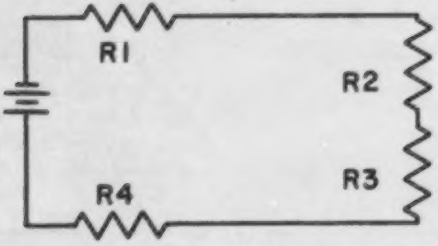


Figure 1B. - Series circuit.

- In answering questions 1-31 through 1-35, refer to figure 1B. Assume the following values: current = 2 amps, R1 = 3 ohms, R2 = 6 ohms, R3 = 6 ohms, and R4 = 3 ohms.

1-31. Compute the total resistance.

1. $R_T = \dfrac{1}{\frac{1}{3}+\frac{1}{6}+\frac{1}{6}+\frac{1}{3}} = 1$ ohm
2. $R_T = \dfrac{1}{\frac{1}{3}+\frac{1}{3}} + \dfrac{1}{\frac{1}{6}+\frac{1}{6}} = 4.5$ ohms
3. $R_T = 6 + \dfrac{1}{\frac{1}{3}+\frac{1}{3}} + 6 = 13.5$ ohms
4. $R_T = 3 + 6 + 6 + 3 = 18$ ohms

1-32. Compute the voltage drop in R2.

1. 0.33 V
2. 3.0 V
3. 12.0 V
4. 36.0 V

- In questions 1-33 and 1-34, judge each statement as True or False.

1-33. The voltage drop across R2 is equal to the sum of the voltage drops across R1 and R4.

1-34. The value of the current changes as it passes each resistor, changing twice as much upon passing R2 as it does upon passing R1.

1-35. What is the value of the power drop at R1?

1. 6 W
2. 12 W
3. 24 W
4. 36 W

Learning Objective: Define various common electrical terms.

1-36. In a circuit, the term "ground" refers to

1. an area of fluctuating magnetic flux surrounding a conductor
2. the total source voltage of a direct-current-powered circuit
3. a common reference point whose potential is usually at or near zero volts
4. a conductor, such as a wire, which is attached to both ends of a resistor to provide a low-resistance path for current

1-37. "Short circuit" is the term applied to

1. an unintentional path of low resistance by which a high value of current can bypass its intended path
2. a circuit which is totally in series and which has only one source of power
3. a circuit which is nonconducting because of an open switch, broken wire, etc.
4. a circuit in which there is a sudden drop in current flow because of excessively high resistance

Learning Objective: Compute values of voltage, current, resistance, and power in a parallel circuit.

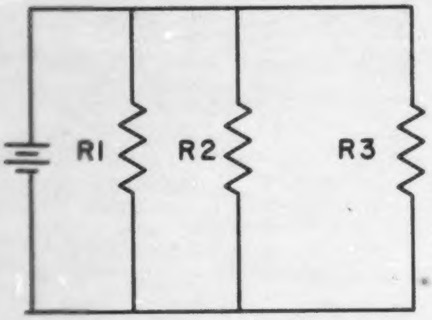


Figure 1C. - Parallel circuit.

- Refer to figure 1C in answering questions 1-38 through 1-42.

1-38. Assume the source voltage to be 60 volts and the total resistance to be 10 ohms. Compute the total power.
1. 6 W
2. 60 W
3. 360 W
4. 600 W

1-39. What is the source voltage if I = 4 amps and R_T = 16 ohms?
1. 0.25 V
2. 4.0 V
3. 20.0 V
4. 64.0 V

1-40. If source voltage = 30 volts, R1 = 5 ohms, R2 = 10 ohms, and R3 = 15 ohms, what is the voltage drop impressed across R2?
1. 0.909 V
2. 2.727 V
3. 10.0 V
4. 30.0 V

- Judge whether the statements in questions 1-41 and 1-42 regarding circuit values are True or False, assuming the following values: source voltage = 30 volts, R1 = 5 ohms, R2 = 10 ohms, and R3 = 15 ohms.

1-41. The voltage drop across R1 is one-half the value of that across R2.

1-42. R1 draws three times the amount of current that R3 does.

Learning Objective: Compute values of voltage, current, resistance, and power in a series-parallel circuit.

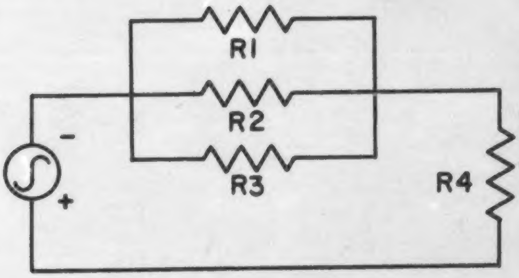


Figure 1D. - Series-parallel circuit.

- Refer to figure 1D in answering questions 1-43 through 1-45.

1-43. What is the total resistance if R1 = 2 ohms, R2 = 4 ohms, R3 = 2 ohms, and R4 = 4 ohms?
1. 1.5 ohms
2. 4.8 ohms
3. 8.25 ohms
4. 12.0 ohms

1-44. If the source voltage is 60 volts, and the resistors are as follows: R1 = 2 ohms, R2 = 2 ohms, R3 = 2 ohms, and R4 = 4 ohms, approximately what is the circuit current?
1. 4.67 A
2. 10.91 A
3. 12.85 A
4. 105.08 A

1-45. What is the source voltage if the circuit is 3 amps, the total (or equivalent) resistance of R1, R2, and R3 is 2.5 ohms, and R4 = 10 ohms?
1. 0.24 V
2. 6.0 V
3. 31.2 V
4. 37.5 V

Learning Objective: Define direct and alternating current.

1-46. Which, if any, of the following definitions correctly defines direct current?
1. Current characterized by intermittent, rather than continuous, flow
2. Current which flows in one direction only
3. Current which can flow only through the single, direct conductance path of a series circuit
4. None of the above

1-47. Which, if any, of the following definitions correctly defines alternating current?
1. Current derived, alternately, from two power sources; i.e., two batteries
2. Current which repeatedly reverses direction of flow
3. Current which alternates among the conductance paths of a parallel circuit
4. None of the above

Learning Objective: Explain the function of an a.c. generator, and determine the frequency of a generated a.c. current when the number of poles in the generator and the rotation rate of the loop are known.

1-48. (a) What is the function of the a.c. generator, and (b) by what means does it accomplish this function?
1. (a) Converting mechanical energy into electrical energy,
   (b) by electromagnetic induction
2. (a) Converting electrical energy into rotating mechanical energy,
   (b) by electromagnetic induction
3. (a) Converting a low direct voltage to a low alternating voltage and applying it to a power transformer,
   (b) by the use of power packs
4. (a) Adjusting the phase of the output current or voltage relative to the phase at the input,
   (b) by the use of a phase shifter

● Use the following information in answering questions 1-49 and 1-50: A certain a.c. generator has a rotating loop, or armature, that makes a complete rotation every one-twentieth of a second within a stator which has one pair of poles.

1-49. What is the frequency of the current generated?
1. 1/20 Hz
2. 1/10 Hz
3. 20 Hz
4. 40 Hz

1-50. If we were to plot this a.c. current for one minute, how many sine waves would be plotted?
1. 10
2. 20
3. 600
4. 1200

1-51. What is the output frequency of an a.c. generator which has three north and three south poles, and which is rotating at 2400 rpm?
1. 60 Hz
2. 120 Hz
3. 60 kHz
4. 120 kHz

Learning Objective: Name various sine wave amplitude measurements and relate them properly to a sine wave.

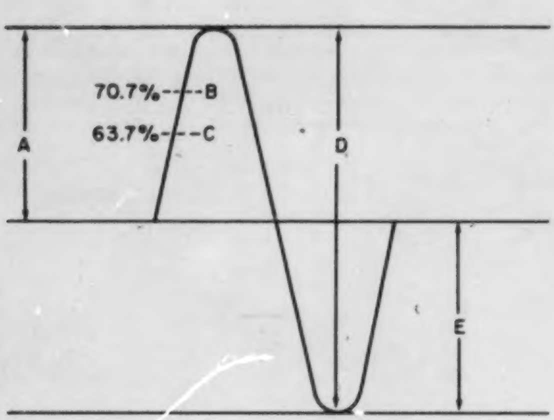


Figure 1E. - Sine wave values.

- Refer to figure 1E in answering question 1-52.

1-52. What wave amplitude measurement values are represented by A, B, C, D, and E respectively?
1. Peak-to-peak, average, effective, positive peak, negative peak
2. Negative peak, effective, average, peak-to-peak, positive peak
3. Positive peak, effective, average, peak-to-peak, negative peak
4. Positive peak, average, effective, peak-to-peak, negative peak

---

To answer questions 1-53 through 1-56, select from column B the electrical property defined in column A.

A. Definitions

1-53. Measure of the number of cycles of current per second

1-54. The property of an electrical circuit that opposes any change of current

1-55. A term used to describe the relative positions of the sine waves of two or more currents or voltages existing at the same time

1-56. The property of an electrical circuit that opposes any change of voltage

B. Electrical Properties

1. Capacitance
2. Frequency
3. Inductance
4. Phase relationship

Learning Objective: Determine why self-inductance is greater in a.c. than d.c. circuits, distinguish the relative inductivity of listed conductors, and compute inductance in series and parallel circuits.

1-57. Self-inductance is more pronounced in a.c. than d.c. circuits. What is the explanation for this fact?
1. The occurrence of flux change (flux expanding or collapsing) is much more pronounced in a.c. than in d.c. circuits
2. After current reaches its peak in d.c. circuits, the magnetic field around the conductor collapses and becomes nonexistent
3. The peak value of a.c. current in a circuit is usually greater than the peak value of d.c. current
4. Because the effective value of a.c. current is less than its peak value, the measure of its self-inductance is greater than that of d.c. current

1-58. What is the total inductance in a series circuit having well-shielded inductors of 5 mH and 10 mH?
1. 0.07 mH
2. 0.3 mH
3. 3.33 mH
4. 15.0 mH

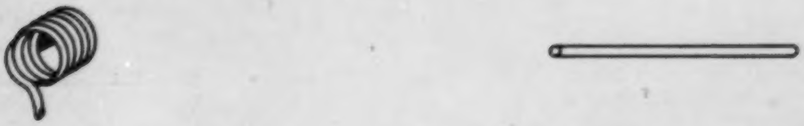
1-59. What is the total inductance in a parallel circuit having well-shielded inductors of 3 mH, 3 mH, and 6 mH?
1. 0.083 mH
2. 0.833 mH
3. 1.2 mH
4. 12.0 mH

- Refer to figure 1F in answering question 1-60.

1-60. Other factors (length, diameter, etc.) being equal, what would be the relative degree of inductivity of the illustrated conductors, listed from highest to lowest?
1. C, D, B, A
2. B, C, A, D
3. C, B, A, D
4. C, B, D, A

A. Loosely-coiled air-core conductor

C. Tightly-coiled iron-core conductor



B. Tightly-coiled air-core conductor

D. Straight length of wire

Figure 1F. - Conductors of various inductances.

Learning Objective: Identify the phase relationship of current, applied voltage, and induced voltage in an inductive circuit.

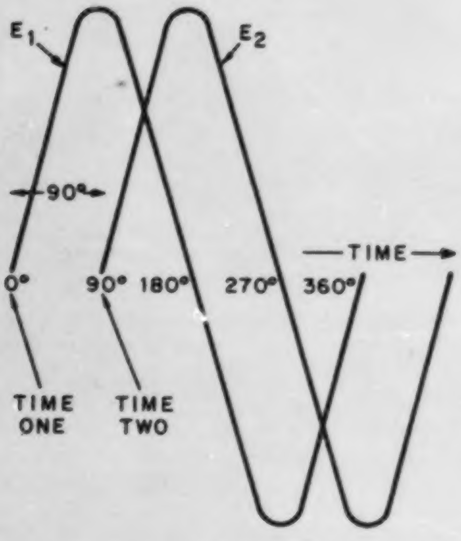


Figure 1G. - Phase relationship of sine waves.

● Refer to figure 1G in answering question 1-61.

1-61. What is the phase relationship between voltages E1 and E2?
   1. E1 leads E2 by 90°
   2. E2 leads E1 by 90°
   3. E1 lags E2 by 180°
   4. E2 lags E1 by 180°

1-62. Which of the following phase relationships exists in an inductive circuit?
   1. The current lags the applied voltage by 90° and is in phase with the induced voltage
   2. The current lags the applied voltage by 90° and lags the induced voltage by 45°
   3. The current lags the applied voltage by 45° and leads the induced voltage by 45°
   4. The current lags the applied voltage by 90° and leads the induced voltage by 90°

Learning Objective: Explain how to increase the capacitance of a capacitor, recognize possible results of dielectric leakage and of exceeding the voltage rating of a capacitor, and compute capacitance in series and parallel circuits.

1-63. Which of the following groups of actions lists three ways to increase the capacitance of a capacitor?
1. Increasing the area of the plates; decreasing the distance between the plates; increasing the dielectric constant
2. Decreasing the area of the plates; increasing the distance between the plates; increasing the dielectric constant
3. Increasing the area of the plates; decreasing the distance between the plates; decreasing the dielectric constant
4. Decreasing the area of the plates; increasing the distance between the plates; decreasing the dielectric constant

1-64. A high degree of dielectric leakage in a capacitor could quite possibly cause the capacitor to
1. overcharge and crack or break
2. discharge and become overheated
3. discharge and reverse the flow of current through the circuit
4. overcharge and catch on fire

1-65. If a capacitor is subjected to a level of voltage which exceeds its voltage rating, which of the following conditions is most likely to occur?
1. Dielectric breakdown, arcing between the plates, and the passage of direct current through the capacitor
2. A sharp upswing in the level of capacitance, resulting in rapid, erratic reversals of polarity of the capacitor
3. An instantaneous change in the working voltage of every capacitor in the circuit
4. An outbreak of fire at the capacitor

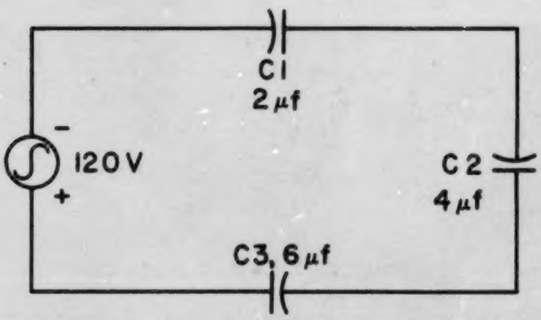


Figure 1H. - Capacitors in a series circuit.

- Refer to figure 1H in answering question 1-66.

1-66. What is the total capacitance in farads (f) of the circuit shown?
1. 0.001 f
2. 0.01 f
3. 100.0 f
4. 1,000.0 f

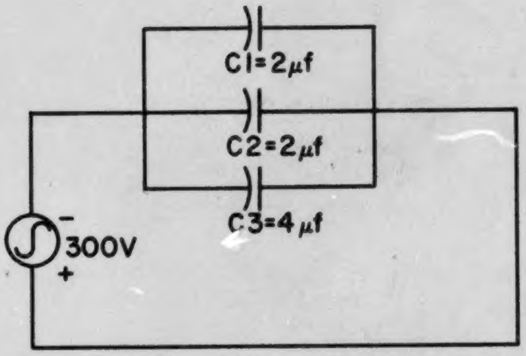


Figure 1J. - Capacitors in a parallel circuit.

- Refer to figure 1J in answering question 1-67.

1-67. What is the total capacitance of the circuit shown?
1. 0.0008 f
2. 0.008 f
3. 125.0 f
4. 1250.0 f

Learning Objective: Identify the schematic symbols for several electrical terms.

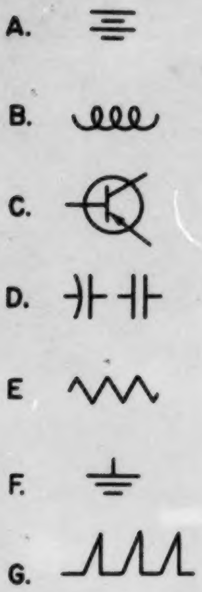


Figure 1K.

- Refer to figure 1K in answering questions 1-68 through 1-72. In each of these questions, select the symbol from figure 1K to match the term given.

1-68. Capacitor
1. B
2. C
3. D
4. E

1-69. Ground
1. A
2. B
3. E
4. F

1-70. Inductor
1. A
2. B
3. C
4. G

1-71. Resistor
1. B
2. D
3. E
4. G

1-72. Battery
1. A
2. D
3. E
4. F

Learning Objective: Determine what properties combine to form impedance; compute inductive reactance; and compute capacitive reactance.

1-73. Impedance is the cumulative effect of which of the following electrical properties?
1. Resistance, capacitance, reactance
2. Capacitance, voltage, current
3. Resistance, inductive reactance, capacitive reactance
4. Inductive reactance, capacitive reactance, capacitance

1-74. If the inductance of a circuit is .65 henrys and it is utilizing a 60-Hz a.c. current, what is the approximate value of its inductive reactance?
1. 0.004 ohm
2. 39.0 ohms
3. 244.92 ohms
4. 489.84 ohms

1-75. If the capacitance of a circuit is .004 farad and it is utilizing a 60-Hz current, what is the approximate value of its capacitive reactance?
1. 0.332 ohm
2. 0.663 ohm
3. 1.507 ohms
4. 3.014 ohms

Assignment 2

Basic Electricity (Continued); Basic Transmitter and Receiver Theory

Textbook Assignment: Pages 20 - 84

Learning Objective: Identify the units of measurement associated with several common electrical properties.

A. Ampere
B. Coulomb
C. Farad
D. Henry
E. Hertz
F. Mho
G. Ohm
H. Volt
I. Watt

List 2A.

- In answering questions 2-1 through 2-8, select from list 2A the unit of measurement used to measure the electrical property given as the question.

2-1. E
1. A
2. B
3. H
4. I

2-2. I
1. A
2. C
3. H
4. I

2-3. R
1. B
2. E
3. F
4. G

2-4. X_C
1. B
2. D
3. F
4. G

2-5. X_L
1. B
2. D
3. F
4. G

2-6. f
1. A
2. D
3. E
4. I

2-7. L
1. C
2. D
3. E
4. F

2-8. C
1. C
2. D
3. E
4. F

Learning Objective: Distinguish among the names, characteristics, and uses of the various bands of frequencies used in radio communications.

A. Relatively long distances can be covered. This is one of the two bands in which most shipboard transmitters and receivers operate. Used extensively by commercial facilities. The international distress signal is in this band.

B. The signal can travel long distances and can go through magnetic storms. This band is used primarily for fleet broadcasts, radio navigation, and transmission of time standards.

C. This band is used for aeronautical radio navigation and communications, radar, and amateur radio.

D. This band is used for long-range direction-finding, medium-, and long-range communications, and aeronautical navigation.

E. This band is used for short-range communications.

F. This band is used primarily by mobile and maritime communication units. This is one of the two bands in which most shipboard transmitters and receivers operate.

List 2B.

- In answering questions 2-9 through 2-14, select from list 2B the description of the frequency band given as the question.

2-9. VLF (3-30 kHz)
1. A
2. B
3. C
4. E

2-10. LF (30-300 kHz)
1. C
2. D
3. E
4. F

2-11. MF (300-3000 kHz)
1. A
2. B
3. C
4. E

2-12. HF (3-30 MHz)
1. A
2. B
3. D
4. F

2-13. VHF (30-300 MHz)
1. B
2. C
3. D
4. F

2-14. UHF (300 MHz - 3 GHz)
1. A
2. D
3. E
4. F

Learning Objective: Identify, from a block diagram, the basic components of a typical transmitter.

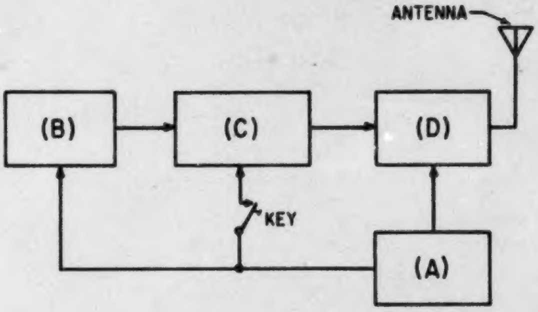


Figure 2A. - Stages of a typical transmitter.

● Refer to figure 2A in answering question 2-15.

2-15. Identify the components of the illustrated transmitter.
1. (A) Oscillator, (B) power supply, (C) buffer-frequency multiplier, (D) power amplifier
2. (A) Oscillator, (B) power supply, (C) power amplifier, (D) buffer-frequency multiplier
3. (A) Power supply, (B) oscillator, (C) buffer-frequency multiplier, (D) power amplifier
4. (A) Power supply, (B) buffer-frequency multiplier, (C) oscillator, (D) power amplifier

---

Learning Objective: Explain the primary functions of the basic components of a CW transmitter.

2-16. What is the purpose of the keying device of a CW transmitter?
1. To start and stop the amplitude modulation process
2. To start and stop the frequency modulation process
3. To turn the internal IF on and off
4. To turn the RF output on and off

2-17. What is the function of an oscillator in a CW transmitter?
1. To produce an a.c. signal which is consistently at the desired frequency and amplitude
2. To produce an a.c. signal which is consistently at the desired frequency, amplify that signal, and maintain the stability of its amplified form
3. To produce and amplify an a.c. signal, filter it, and then maintain frequency and amplitude stability
4. To produce an a.c. signal which is consistently at the desired frequency, and, for reinforcement, vary its amplitude in phase with the current

2-18. What is the purpose of the feedback circuit in a transmitter?
1. To feed the output of the transmitter back through the oscillator to give the signal an additional pulse of voltage
2. To feed the output of the transmitter back through a filter circuit for purification
3. To feed a low-amplitude output signal back to the oscillator to help maintain stable oscillations
4. To feed a low-amplitude output signal back to the amplification circuit to be strengthened

2-19. What is the usual function of the buffer?
1. To measure the amplitude and frequency of the signal from the oscillator and compensate for any variation
2. To provide the final amplification to the signal before it is radiated
3. To measure the amplitude (only) of the signal from the oscillator and compensate for any variation
4. To amplify the signal from the oscillator sufficiently to drive the power amplifier

2-20. One reason for having one or more power amplifiers between the oscillator and the antenna is to increase the strength of the signal. What is another reason for having the amplifier stage in its position in the transmitter?
1. To help maintain frequency stability by blocking the reflection of the antenna impedance to the oscillator
2. To help assure uniform shapes of the waves just prior to their radiation by feeding them through an internal waveshape standardization circuit
3. To help avoid the radiation of overmodulated signals by clipping all parts of the signal beyond certain limitations
4. To help assure a continuous, smooth output (rather than intermittent or broken pulses) from the transmitter

2-21. What voltages/energy are provided to the various circuits by the power supply in a transmitter?
1. Alternating and direct voltages and RF energy
2. Alternating voltages only
3. Direct voltages only
4. Alternating and direct voltages only

2-22. What processes occur in a power supply during (a) rectification and (b) filtering?

1. (a) The sine waves are smoothed (amplitude made more nearly constant),
   (b) the a.c. is changed to pulsating d.c.
2. (a) The sine waves are smoothed (amplitude made more nearly constant),
   (b) the signal is further flattened and smoothed out
3. (a) The a.c. voltage is changed to pulsating d.c.,
   (b) alternate pulses of the d.c. voltage are eliminated
4. (a) The a.c. voltage is changed to pulsating d.c.,
   (b) the pulsating d.c. is smoothed (made more nearly constant)

Learning Objective: Identify the major components of the crystal microphone.

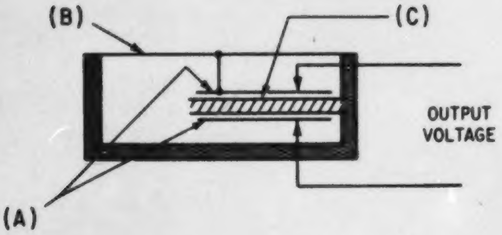


Figure 2B. - Crystal microphone.

- Refer to figure 2B in answering question 2-23.

2-23. Identify, in alphabetical sequence, the lettered items related to the composition or use of a diaphragm-type crystal microphone.

1. (A) Diaphragm, (B) crystal, (C) electrodes
2. (A) Electrodes, (B) diaphragm, (C) crystal
3. (A) Crystal, (B) electrodes, (C) diaphragm
4. (A) Electrodes, (B) crystal, (C) diaphragm

Learning Objective: Explain functions of the basic components of an amplitude-modulated (AM) transmitter.

2-24. What is the function of the driver stage of an AM transmitter?

1. To direct the received signal to a specified path in the circuit
2. To alternately add to and subtract from the plate voltage of the power amplifier
3. To increase the signal to a very large voltage
4. To rectify the incoming a.c. signal

2-25. The modulator emits a relatively high-voltage amplified signal which corresponds in shape to the voice waves received by the microphone. (a) What path is then traveled by this signal, and (b) for what purpose is it directed there?

1. (a) Through one of a pair of twin in-phase connectors directly to the antenna,
   (b) to be transmitted at the same time as the RF carrier
2. (a) To the final power amplifier,
   (b) to modulate the RF carrier
3. (a) Through the wave synchronization stage, a network of filters and oscillators,
   (b) to be merged with the RF carrier
4. (a) To the buffer amplifier for amplification, then through the other intermediate amplifiers (if any), and into the power amplifier,
   (b) to modulate the RF carrier

Learning Objective: Describe amplitude modulation and the resultant amplitude-modulated wave.

2-26. If an RF carrier of 2750 kHz is amplitude-modulated by an audio frequency of 1 kHz, what would be the frequency of the resultant (a) upper sideband, and (b) lower sideband?

1. (a) 2750.1 kHz, (b) 2749.9 kHz
2. (a) 2750.5 kHz, (b) 2749.5 kHz
3. (a) 2751 kHz, (b) 2749 kHz
4. (a) 2760 kHz, (b) 2740 kHz

2-27. When an RF carrier is modulated by a single AM frequency, what percent of the amplitude of the modulating wave is the amplitude of the upper or lower sideband, as can be displayed on a spectrum analyzer?
1. 25%
2. 50%
3. 75%
4. 100%

● In answering questions 2-28 and 2-29, assume that there is a double sideband wave which resulted from the amplitude modulation of a carrier of 10 kHz by signals with frequencies at .3, .5, and 1.2 kHz.

2-28. Select the response that lists all the resultant side frequencies in the modulated wave.
1. .3, .6, .5, 1.0, 1.2, 2.4 kHz
2. 9.7, 10.3, 9.5, 10.5, 8.8, 11.2 kHz
3. 10.3, 10.5, 11.2 kHz
4. 10.3, 10.6, 10.5, 11.0, 11.2, 12.4 kHz

2-29. What is the bandwidth of the modulated wave, measured in kHz?
1. 1.2 kHz
2. 2.4 kHz
3. 11.2 kHz
4. 12.4 kHz

2-30. In the amplitude modulation mode, if the peak voltage of the modulating signal is equal to the supply voltage to the final power amplifier, what will be the degree of modulation?
1. 0%
2. 25%
3. 50%
4. 100%

2-31. If the degree of amplitude modulation is 100%, what will be (a) the RF output voltage on the negative peak of the modulating signal, and (b) the relationship of the maximum RF output voltage on the positive peak of the modulating signal to the amplitude of the unmodulated carrier voltage?
1. (a) One-half that on the positive peak; (b) quadruple
2. (a) One-half that on the positive peak; (b) twice
3. (a) Zero; (b) half
4. (a) Zero; (b) twice

2-32. What is the modulation factor if a carrier wave with a peak amplitude of 300 volts is amplitude-modulated by a 2-kHz wave having a peak amplitude of 180 volts?
1. 0.00
2. 0.011
3. 0.6
4. 1.67

2-33. At 100% amplitude modulation, the sidebands (together) contain one-half as much power as the unmodulated carrier. If the degree of modulation is reduced to 50%, what then is the relationship of the power of the sidebands (together) to that of the unmodulated carrier?
1. One-eighth
2. One-fourth
3. Three-fourths
4. The same

Learning Objective: Explain functions of the basic components of a single sideband (SSB) transmitter.

2-34. What type of signal does the SSB generator of a typical SSB transmitter actually produce at the generator stage?
1. Double sideband
2. Single sideband reduced carrier
3. Single sideband suppressed carrier
4. Independent or double single sideband

2-35. The generated signal from the SSB generator of a SSB transmitter passes through a highly selective filter. What is the purpose of the filter?
1. To reject one of the sidebands
2. To trim off all amplitude crests which exceed modulation limits
3. To separate the sidebands and pass them on for separate transmission
4. To reject the carrier and pass the remaining part of its input to the next stage

2-36. After the signal passes through the filter, what action occurs as the signal goes through various mixers and amplifiers?

1. It is mixed with a modulating audio frequency signal
2. It is mixed with the lower-frequency output of a local oscillator to become an intermediate frequency of somewhat lower frequency
3. It is converted to a radio frequency to be transmitted
4. It is checked against the frequency standard circuit, automatically retuned to its original frequency, filtered to remove modulation, and amplified for transmission

2-37. What signal does the carrier generator provide and where is this signal directed?

1. It provides the conversion frequencies necessary to produce the RF SSB signal, which is directed to the mixer-amplifier stage
2. It provides the RF carrier, which is directed straight to the antenna to be merged with the outgoing signal
3. It provides the IF carrier used to produce the IF SSB signal, which is directed to the SSB generator
4. It provides the conversion frequencies necessary to produce the RF SSB signal, which is directed to the SSB generator

---

Learning Objective: Distinguish among the various types of single sideband transmission.

To answer questions 2-38 through 2-41, select from column B the mode of transmission described in column A.

A. Definitions

2-38. The mode of transmission in which a carrier and two sidebands carrying different information are transmitted together

2-39. The mode of transmission in which one sideband is eliminated and the power of the carrier diminished prior to transmission of the signal, and the other sideband and the weakened carrier are transmitted together

2-40. The mode of transmission in which one sideband and the carrier are eliminated prior to transmission of the signal, and then a signal of the same frequency as the carrier is later reinserted by the receiver

2-41. The mode of transmission in which one sideband is eliminated prior to transmission of the signal, and the other sideband and the carrier (without alteration) are transmitted together

B. Modes Of Transmission

1. Single sideband full carrier
2. Single sideband reduced carrier
3. Single sideband suppressed carrier
4. Independent or double single sideband

Learning Objective: State the advantages of transmission by the CW mode as compared to the AM mode, and by the single sideband mode as compared to the AM double sideband mode.

2-42. What advantages has CW transmission, as compared to amplitude-modulated signal transmission?

1. High fidelity of vocal tone reproduction; good penetration of heavy noise conditions by the signal; long-range capability
2. High fidelity of vocal tone reproduction; good penetration of heavy noise conditions by the signal; narrow bandwidth
3. Long-range capability; good penetration of heavy noise conditions by the signal; narrow bandwidth
4. Long-range capability; narrow bandwidth; strengthened signal because of its reinforcement and amplification by phase relationship between the RF and IF segments of the wave

2-43. Two of the advantages of single sideband transmission (disregarding independent sideband) over double sideband transmission are reduced bandwidth and increased effective power, therefore, increased range. What are two other advantages?

1. Less distortion and less interference
2. Less distortion and much higher rate of travel of signal through space
3. Less interference and much higher rate of travel of signal through space
4. Lower distortion and reduced size of the antenna required

Learning Objective: Define amplitude modulation and frequency modulation, and explain some of the principles involved in FM.

● Judge whether questions 2-44 through 2-48 are True or False.

2-44. Intelligence can be superimposed on a carrier in the form of changes in the amplitude of the carrier. This is known as amplitude modulation (AM).

2-45. Intelligence can be superimposed on a carrier in the form of changes in the frequency of the carrier. This is known as frequency modulation (FM).

2-46. In FM, the amount the carrier is varied depends on the frequency of the modulating signal.

2-47. In FM, the rate at which the carrier is varied depends on the amplitude of the modulating signal.

2-48. In FM, the amplitude of the RF remains constant, both during and between periods of modulation.

2-49. If a carrier with a frequency of 29,500 kHz is frequency modulated by a signal with a frequency of 2 kHz, the first set of sideband frequencies is 29,498 and 29,502 kHz. What are the frequencies of the second and third sets?

1. 29,497 and 29,503 kHz;
   29,496 and 29,504 kHz
2. 29,496 and 29,504 kHz;
   29,494 and 29,506 kHz
3. 29,496 and 29,504 kHz;
   29,492 and 29,508 kHz
4. 29,494 and 29,506 kHz;
   29,488 and 29,512 kHz

2-50. The number of sideband frequencies of a frequency-modulated wave is theoretically infinite. The bandwidth of an AM wave, however, has been set by definition to be the frequency range between the extreme upper and extreme lower sidebands having amplitudes that are at least what percent of the amplitude of the unmodulated carrier?

1. 1%
2. 2%
3. 5%
4. 10%

2-51. What are the frequency and distortion characteristics of wideband FM, relative to narrowband FM?

1. High frequency, low distortion
2. High frequency, high distortion
3. Low frequency, low distortion
4. Low frequency, high distortion

2-52. What is the formula for finding the modulation index in FM if you are given the frequency deviation of the carrier (Fd) and the frequency of the highest modulating signal (Fm)?

1. $M = Fd \times Fm$
2. $M = \frac{1}{Fd \times Fm}$
3. $M = \frac{Fd}{Fm}$
4. $M = \frac{Fm}{Fd}$

2-53. What is meant by 100% modulation, as related to the description of a frequency-modulated signal?

1. The amplitude of the envelope varies between zero and twice its normal unmodulated value
2. The carrier is deviated in frequency by the full permissible amount
3. Deviation of the carrier occurs 100% of the time
4. The power output varies from a null (zero) to a point twice that required for unmodulated transmission

---

Learning Objective: Explain the purposes of some of the safety equipment and safety practices associated with the handling of transmitters.

2-54. What is the purpose of the interlocks in a transmitter?

1. To lock the access doors securely to prevent their being opened by unauthorized personnel
2. To provide a secondary fastener for access doors to prevent them from opening accidentally when the equipment is in a moving ship or aircraft
3. To provide safe, well-insulated connectors by which other equipment may be linked and "interlocked" to the transmitter safely
4. To turn off the power to the transmitter automatically when an access door is opened

2-55. Before touching any of the inner components of a transmitter with your hand, it is important that you first probe about inside with a metal rod with a wooden handle. (a) What do you call this rod, and (b) what is the primary purpose of your probing about?

1. (a) Breakage-detector rod;
   (b) to tap the components to see if any of them appear to be cracked or broken
2. (a) Component-security rod;
   (b) to tap the components to see if all of them are tightly seated and securely connected
3. (a) Shorting bar;
   (b) to touch each part of the circuitry that may carry a charge stored by a capacitor, causing it to discharge by means of a ground connection from the shorting bar
4. (a) Power-detection rod;
   (b) to assure, by means of spark detection, that the power to the transmitter has been turned off

---

Learning Objective: Identify characteristics, define terms, and explain procedures associated with the use of the superheterodyne AM receiver.

2-56. What is the form and composition of the radio signal to be received by an AM superheterodyne receiver?

1. A modulated RF signal, composed of an RF signal upon which an AF signal has been impressed
2. An unmodulated RF signal (carrier), composed of an intermittent RF signal which does not vary in amplitude, but does vary in frequency according to the information it carries
3. A modulated RF signal, composed of an RF signal upon which a second RF signal of higher frequency has been impressed
4. A modulated IF signal, composed of an RF signal which has been modified and modulated by an IF signal

2-57. Relative to receivers, what is meant by the term "sensitivity"?
1. The ability of a receiver to reproduce a weak signal
2. The susceptibility of a receiver to misalignment or drift
3. The degree of physical fragility of a receiver
4. The ability of a receiver to differentiate among closely-spaced signals and reproduce the desired signal

2-58. Relative to receivers, what is meant by the term "selectivity"?
1. The ability of a receiver to reproduce a weak signal
2. The ability of a receiver to select either CW, AM, or FM signals at its antenna and RF amplifier stages
3. A measure of the ease with which a receiver selects the carrier or a specified sideband from the full signal
4. The ability of a receiver to differentiate among closely-spaced signals and reproduce the signal desired

2-59. Which of the following is a term which means the combining of two or more frequencies to produce new frequencies?
1. Squelching
2. Heterodyning
3. Demodulating (or detecting)
4. Oscillating

2-60. What function of a receiver takes place when a transmitted electromagnetic wave cuts across the receiver antenna in such a way as to induce a voltage in the antenna circuit?
1. Detection
2. Reception
3. Modulation
4. Mixing

2-61. The cutting of electromagnetic waves across the antenna induces very small a.c. voltages which are then fed to one or more frequency-selection circuits located at the input to the receiver. Which of the following is a function of these frequency-selection circuits?
1. To select the desired frequency and reject all others
2. To synchronize the carrier and sidebands so that they will be in phase
3. To remove the carrier and one sideband from the signal
4. To amplify the signal to the level necessary to drive the next stage

2-62. What is the next thing that happens to the RF signal from the antenna after it goes through the input tank?
1. It is heterodyned
2. It is amplified by an RF amplifier
3. It is detected or demodulated
4. It is processed through the beat frequency oscillator

2-63. What two signals go to the mixer of a superheterodyne receiver?
1. A locally-produced intermediate-frequency signal and a signal, the frequency of which is the difference between the incoming RF and the IF
2. The incoming RF signal and an IF signal which is usually 455 kHz
3. The incoming RF signal which has been amplified, and a constant-amplitude RF signal from a local oscillator
4. The incoming RF signal and a signal, the frequency of which is the difference between that of the carrier and the outer side frequency of either the upper or lower sideband

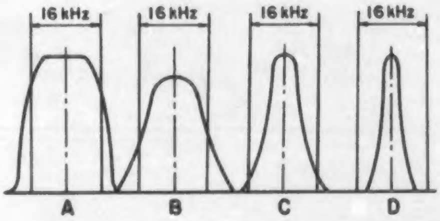


Figure 2C.

● Refer to figure 2C in answering questions 2-64 through 2-67. Sharper tuning is desired in the RF amplifier stages of some receivers than of others, depending upon the purpose of the reception. In each question, select the tuning curve (indicating sharpness of tuning) associated with the type of receiver named.

2-64. CW
1. A
2. B
3. C
4. D

2-65. FM (commercial)
1. A
2. B
3. C
4. D

2-66. AM (commercial)
1. A
2. B
3. C
4. D

2-67. AM voice communication (military)
1. A
2. B
3. C
4. D

2-68. What will be the frequency of the local oscillator of a superheterodyne receiver if the IF is 455 kHz and the incoming RF is 1655 kHz?
1. 455 kHz
2. 1200 kHz only
3. 2110 kHz only
4. Either 1200 kHz or 2110 kHz

2-69. If the RF input to a superheterodyne receiver is 1655 kHz and the IF is 455 kHz, what are the major frequency outputs of the mixer?
1. 1655, 455, 1200, and 2110 only
2. 1655, 455, 1200, 2110, 2855, and 3765
3. 455, 1200, and 2855 only or 455, 2110, and 3765 only
4. 1655, 455, 1200, and 2855 only or 1655, 455, 2110, and 3765 only

---

Learning Objective: Describe the various stages of a receiver. (This objective is continued in Assignment 3.)

A. Among other functions performed, components in this stage isolate the oscillator from the antenna-ground systems.

B. From this final stage of the superheterodyne receiver the signals go to a speaker, headphone, or other such device.

C. Practically all the selectivity of a superheterodyne receiver is determined by this stage, supplemented by some selectivity provided by another amplifier stage.

D. The sensitivity of a receiver is accomplished primarily in this stage.

E. It is especially important at this stage to output an adequate signal with a high signal-to-noise ratio so that it can be picked up in the noisy stage ahead.

F. This stage is called the preselector.

List 2C.

● In questions 2-70 through 2-72, select from list 2C the description or characteristic that matches the receiver stage named.

2-70. AF amplifier
1. A
2. B only
3. E only
4. B and E

2-71. IF amplifier
1. C
2. D
3. E
4. F

2-72. RF amplifier
1. A, D, and F only
2. B and C only
3. B, C, and E
4. A, D, E, and F

A. Small voltages developed in this stage by the RF signal are sent to frequency-selection circuits for acceptance or rejection.

B. From this final stage of the superheterodyne receiver the signals go to a speaker, headphone, or other such device.

C. This stage generates the majority of the receiver noise because of the input of voltages that differ in frequency and phase from existing voltages.

D. The function of this stage is frequency conversion by heterodyne action.

E. A signal, the frequency of which is a specified frequency deviation from the incoming RF signal, is generated here.

F. At this stage a reproduction of the original AF modulation is recreated from the IF signal.

List 2D.

● In questions 2-73 through 2-75, select from list 2D the description or characteristic that matches the receiver stage named.

2-73. Detector
1. B
2. D
3. E
4. F

2-74. Local oscillator
1. A
2. C only
3. E only
4. C and E

2-75. Mixer
1. A and C
2. A and D
3. C and D
4. F

Assignment 3

Basic Receiver Theory (Continued); Basic Antenna Theory; Radio Wave Propagation

Textbook Assignment: Pages 83 - 115

Learning Objective: (Continued) Describe the various stages of a receiver.

3-1. If you change the setting of the receiver to receive RF of a different frequency, how is the frequency of the local oscillator adjusted so there will still be the same amount of difference in frequency between them?
1. The tuned circuits of the RF stage and the local oscillator are connected to the same tuning shaft
2. When the RF signal changes frequency, a red frequency synchronization light comes on, and remains on until the "Osc Tune Knob" on the front panel is properly adjusted (manually)
3. There is a feed-back circuit from the RF tuned tanks to the local oscillator circuit. Any change in frequency causes an electronic adjustment to be made
4. The operator should press the black button on the panel and hold it in for five seconds. This will initiate an electronic adjustment

3-2. Why can the tuned circuits in the IF amplifier stage be permanently adjusted for optimum gain and bandwidth characteristics, but those in the RF amplifier stage can NOT?
1. Because the signals present in the IF amplifier stage are of lower frequency than those in the RF amplifier stage
2. Because the signals present in the IF amplifier stage are of higher frequency than those in the RF amplifier stage
3. Because the IF amplifier operates at only one frequency, and the tuned circuits of the RF amplifier stage are variable
4. Because the RF amplifier operates at only one frequency, and the tuned circuits of the IF amplifier stage are variable

3-3. What types of signals are (a) the input to and (b) the output from the detector or demodulator stage?
1. (a) An amplified IF signal,
   (b) a small AF signal
2. (a) A small IF signal,
   (b) an amplified AF signal
3. (a) An amplified RF signal,
   (b) a small IF signal
4. (a) A small IF signal,
   (b) a small RF signal

3-4. To what stage of the receiver does the signal go from the detector or demodulator?
1. The IF amplifier
2. The AF amplifier
3. The RF amplifier
4. The final tuning circuit

Learning Objective: Distinguish among various control circuits in a receiver, and give a general description of their operation.

● If a receiver had NO control to compensate for the variation in strengths of signals it receives, there would be a corresponding wide variation of volume in receiver output. In addition, very strong signals would overdrive the RF stage, and the output would be distorted and difficult to understand.

3-5. One way the problems connected with the varied strength of incoming signals could be overcome is by adjusting the manual gain control (MGC), labeled "MANUAL," "MGC," or "MANUAL-GAIN" on the panel. What normally happens internally when this knob is turned?
1. The amplification factor of the AF stage is varied
2. The strength of the signal from the local oscillator to the mixer is varied
3. The amplification factor of the RF stage is varied
4. The strength of the IF signal from the mixer is varied

3-6. The automatic gain control (AGC) works somewhat differently from the MGC. How does the AGC work?

1. A proportional amount of the incoming RF signal is sent to the IF amplification stage where it attenuates (weakens) the signals in direct proportion to their strengths
2. A capacitive/inductive filter, inserted at the output of the RF amplification stage, attenuates, in proportion to their strengths, all signals with amplitudes exceeding a set amount
3. It filters and feeds a proportional part of the d.c. component of the output of the detector stage, which varies as the strength of the signals received, to each of the preceding stages to attenuate the signals in proportion to their strengths
4. A capacitive/inductive filter, inserted at the output of the AF amplification stage, attentuates, in proportion to their strengths, all signals with amplitudes exceeding a set amount

3-7. How does the action of the delayed gain control differ from that of the AGC?

1. The primary difference is that in delayed gain control there is a slight delay (measured in nanoseconds) after the initiating signal triggers a response
2. When delayed gain control is used, attenuation occurs one stage later than when AGC is used
3. When delayed gain control is used, attenuation occurs two stages later than when AGC is used
4. When delayed gain control is used, no degenerative feedback is developed if the signal strength is less than a certain value

3-8. What is the purpose of the beat frequency oscillator (BFO)?

1. To make it possible to have an AF output from a received CW signal
2. To attenuate very strong signals to prevent their overdriving later stages of the receiver
3. To perform an important step in the process of separating one sideband from the rest of the signal
4. To provide regenerative feedback in order to increase the sensitivity of the receiver

3-9. What is the purpose of the squelch, also called the noise-silencer, noise-suppressor, and noise-limiter?

1. To attenuate very strong signals in order to prevent their overdriving the remaining stages in the receiver
2. To suppress receiver noise output when no input signal is being received
3. To suppress the electronic "whine" of the RF amplification stage
4. To reject signals of other than the desired frequency should the receiver drift off frequency

3-10. How is the purpose of the squelch accomplished?

1. By proportional blocking of the RF amplifier stage output
2. By blocking the detector or audio amplifier when there is no signal
3. By the insertion of an inductive/capacitive filter at the output of the last RF amplifier
4. By inserting a matched-frequency stage which passes matching frequencies and rejects all others

3-11. What is the purpose of the automatic frequency control (AFC)?

1. To cause the frequency of the local oscillator to change in proportion to that of the incoming RF signal when the operator changes receiving frequencies
2. To notify the operator of a variance in the IF signal
3. To notify the operator if the frequency selected is outside the range of those designated for use by the Navy
4. To maintain a constant frequency separation between the carrier and local oscillator despite drift of either or both

3-12. What is the method by which the purpose of the AFC is accomplished?
1. A discriminator circuit senses any change in IF, produces a d.c. voltage equivalent to the frequency shift, and feeds this voltage to a reactance circuit, which then causes the local oscillator to change frequency
2. When a new frequency is selected on the panel, a small voltage is fed from the amplifiers in the preselector stage to both the detector stage and the local oscillator, thus causing a realignment of local oscillator frequency
3. If the IF varies, a small voltage is induced in an auxiliary circuit, which then causes a red signal light on the panel to come on
4. If the frequency is outside authorized limits, a small voltage is induced in an auxiliary circuit, which then causes a red signal light on the panel to come on

---

Learning Objective: Explain some of the principles, procedures, and terms associated with the tuning of antennas.

3-13. Varying operating frequencies require varying antenna lengths for optimum radiation. As it would NOT be practical to try to have a separate antenna for each operating frequency, how is this requirement usually met?
1. A stock of about six antennas of different lengths is maintained for each piece of communication equipment, and the one that most nearly matches the operating frequency is used
2. An antenna coupler changes the electrical length of the antenna in order to tune it to the operating frequency
3. Each piece of communication equipment is locked to one operating frequency and is equipped with an antenna specifically selected for that frequency
4. Antennas with telescoping arms are used, and their lengths are physically changed as the operating frequencies are changed

3-14. What term, when used to describe an antenna, means that the antenna is matched to the operating frequency?
1. Harmonized
2. Synchronized
3. Resonant
4. Polarized

3-15. When the length of an antenna is optimum for the operating frequency, what is the relationship between capacitive and inductive reactance?
1. They equal each other
2. The value of X_L is twice that of X_C
3. The difference in value between capacitive and inductive reactance is at its maximum, with capacitive reactance being the stronger
4. The difference in value between capacitive and inductive reactance is at its maximum, with inductive reactance being the stronger

3-16. If four standing-wave ratio (SWR) readings are 2:1, 3:1, 7:1, and 9:1, which of the readings indicates the best SWR?
1. 2:1
2. 3:1
3. 7:1
4. 9:1

Learning Objective: Define or state terms associated with the signal input point and the characteristic impedance of an antenna, and state the relationship between frequency and impedance.

3-17. The RF cable from the transmitter may be connected to the end or center of the antenna. What is the term for the point of connection?
1. Signal point
2. Point of characteristic impedance
3. Point of resonance
4. Feed point

3-18. What is meant by the characteristic impedance of an antenna?
1. The ratio of the inductive reactance to the capacitive reactance when the antenna is properly tuned
2. The ratio of the capacitive reactance to the inductive reactance when the antenna is properly tuned
3. The ratio of the overall resistance of a particular antenna to the resistance of a standard antenna of pure copper of specified dimensions
4. The amount of resistance the antenna is designed to offer when it is properly tuned

3-19. As the frequency in a circuit increases, in which direction do (a) capacitive reactance and (b) inductive reactance vary?
1. (a) Increases, (b) decreases
2. (a) Increases, (b) increases
3. (a) Decreases, (b) decreases
4. (a) Decreases, (b) increases

Learning Objective: Demonstrate the relationship among frequency, wavelength, and antenna length.

3-20. If the operating frequency is 146 MHz, what is the approximate wavelength in feet?
1. 2.05 ft
2. 6.74 ft
3. 2,054,794.52 ft
4. 6,739,726.03 ft

3-21. What should be the physical length, in feet, of a half-wave antenna transmitting at a frequency of 500 MHz?
1. 0.935 ft
2. 0.984 ft
3. 1.870 ft
4. 1.968 ft

Learning Objective: Point out some of the basic principles concerning wave polarization, directivity, and field intensity of antennas.

- Judge whether questions 3-22 through 3-25 regarding polarization of antennas are True or False.

3-22. A vertical antenna radiates a vertically-polarized radio wave.

3-23. The electric field around a vertical antenna is vertical.

3-24. When antennas are less than one wavelength from the ground, horizontally-polarized waves yield a stronger signal close to the earth than do vertically-polarized waves.

3-25. Horizontally-polarized antennas should be used for reception of vertically-polarized waves, whenever possible.

3-26. Of what characteristic is the sharpness or narrowness of the radiation pattern of an antenna a measure?
1. Sensitivity
2. Selectivity
3. Directivity
4. Polarity

- Use the following as the alternatives for questions 3-27 through 3-29. Select the response that correctly states the number of directions in which the specified type of antenna radiates or receives efficiently.

1. One direction only

2. Two directions only

3. All directions except off of the ends

4. All directions

3-27. Omnidirectional

3-28. Unidirectional

3-29. Bidirectional

3-30. Describe the standard antenna used as a reference when field intensity is being measured.
1. Parabolic antenna, exactly one meter in diameter
2. Parabolic antenna, the radial of which is exactly one meter
3. Standard wire antenna, exactly one meter long
4. Standard center-fed wire antenna, exactly two meters long (one meter from center connection to antenna end)

Learning Objective: Point out relationships among current, resistance, and radiated power, and among incident waves, reflected waves, and SWR.

3-31. If the current fed into an antenna is 5 amperes and the radiation resistance is 4 ohms, what is the value of the power being radiated?
1. 20 W
2. 80 W
3. 100 W
4. 400 W

3-32. When the antenna is in resonance, what is the relationship among incident waves, reflected waves, and standing wave ratio (SWR)?
1. The incident waves and reflected waves, being in phase, reinforce each other and cause the SWR to be better
2. The incident waves and reflected waves, being out of phase, tend to cancel each other out and cause the SWR to be poorer
3. At resonance, the incident waves disappear; therefore, the reflected waves are neither reinforced nor canceled, and the SWR is unaffected
4. At resonance, the reflected waves disappear; therefore, the incident waves are neither reinforced nor canceled, and the SWR is unaffected

Learning Objective: Explain some general principles of half-wave antenna theory.

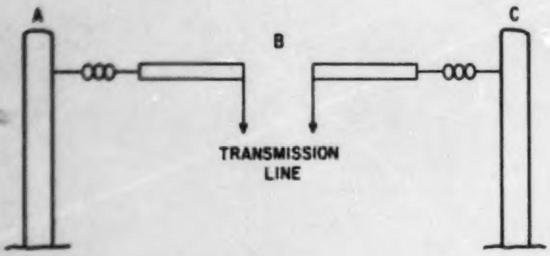


Figure 3A.

● Refer to figure 3A, a resonant half-wave antenna, when answering questions 3-33 through 3-35.

3-33. Which, if any, of the following is the electrical length of the antenna from point A to point C, relative to wavelength?
1. One-quarter wavelength (a.c. must travel this distance twice each half-wave)
2. One-half wavelength
3. One wavelength (one-half wavelength from the center to each end)
4. None of the above

3-34. In what direction(s) does the current flow?
1. Alternating C to A, A to C, etc.
2. Alternating center to ends, ends to center, etc.
3. Center to ends (no reversal)
4. Pulsing current from the center to the ends alternating with periods of no current

3-35. At point B, what is the degree of current, voltage, and impedance?
1. Current minimum, voltage maximum, impedance minimum
2. Current maximum, voltage minimum, impedance minimum
3. Current maximum, voltage minimum, impedance maximum
4. Current minimum, voltage maximum, impedance maximum

3-36. Which of the following statements relating to the radiation pattern of a dipole antenna is correct?
1. The degree of radiation is the same in all directions with no exceptions
2. Radiation occurs only in a plane perpendicular to the axis of the antenna
3. Maximum radiation is in a plane perpendicular to the axis of the antenna; minimum radiation is from the ends of the antenna
4. Minimum radiation is in a plane perpendicular to the axis of the antenna; maximum radiation is from the ends of the antenna

Learning Objective: Explain some general principles of quarter-wave antenna theory.

3-37. You were told in half-wave theory that a half-wave antenna is the shortest practical length for the propagation of radio waves. How, then, can a quarter-wave antenna be used?

1. A special capacitor/inductor circuit at the point of signal input to the antenna doubles the electrical length of the antenna
2. The quarter-wave antenna has, within a fiberglass sleeve, an insulator wound with the amount of antenna wire required to cause the antenna to achieve half-wave characteristics
3. A mirror-image of the same length as the antenna appears to reflect from the ground, causing the antenna to achieve half-wave characteristics
4. A quarter-wave antenna has within it a layer of heat-sensitive oxide which responds to the input of current and causes the antenna to achieve half-wave characteristics

3-38. How much field strength variation, if any, is there at different points of the resultant field surrounding an operating quarter-wave antenna?

1. There is considerable variance because of wave reinforcement and cancellation
2. There is considerable weakness directly above the antenna end, but very little variance elsewhere
3. There is only a slight amount of variance
4. There is no variance, as an electronic control compensates for any potential variance which might be caused by wave reinforcement and cancellation

Learning Objective: Define diffraction, reflection, and refraction.

In questions 3-39 through 3-41, select from column B the term best defined by the definition in column A.

	A. Definitions	B. Terms
3-39.	The bending of a wave around a solid object	1. Diffraction 2. Reflection
3-40.	The bending of a wave when it enters a medium of a different density	3. Refraction 4. Retrocession
3-41.	The bouncing back of a wave from a relatively smooth surface which is larger than the wavelength of the incident wave	

Learning Objective: State the correct sequence of the three regions of the Earth's atmosphere, and identify some of the characteristics of the ionosphere and troposphere.

3-42. What is the correct sequence, from the Earth outward, of the three regions of the Earth's atmosphere?

1. Ionosphere, stratosphere, troposphere
2. Troposphere, stratosphere, ionosphere
3. Stratosphere, troposphere, ionosphere
4. Troposphere, ionosphere, stratosphere

3-43. To what degree do variations in the properties of humidity, temperature, and pressure, respectively, cause refraction of the radio waves in the lower troposphere?

A. To a negligible degree
B. To a moderate degree -- measurable, but of little real significance
C. To a significant degree

	Humidity	Temperature	Pressure
1.	A	C	C
2.	C	B	A
3.	C	C	C
4.	B	A	B

Learning Objective: State the terms used to designate the areas from the outer limit of the ground wave to the first returning sky wave and from the transmitter to the first returning sky wave.

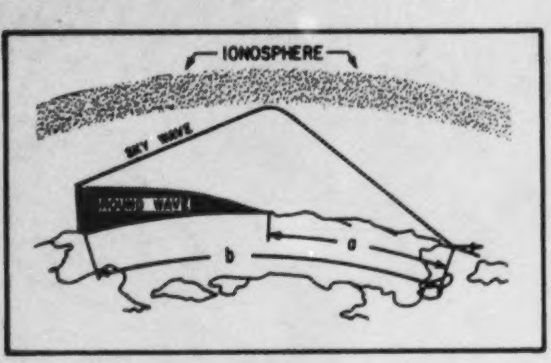


Figure 3B. - Ground waves/sky waves reaching Earth.

- In answering question 3-44, refer to figure 3B.

3-44. What terms are given to the areas labeled "A" and "B," respectively?
1. Skip zone, skip distance
2. Skip interval, skip horizon
3. Skip interval, skip distance
4. Skip distance, skip zone

Learning Objective: Point out some of the causes of and procedures and equipment related to forward propagation tropospheric scatter.

3-45. Forward propagation tropospheric scatter communications is made possible because of the reflection and refraction (scattering) beyond the horizon. What conditions cause the scattering?
1. The rarefied air and partial vacuum present in the troposphere
2. The characteristic quietness and extreme constancy of the troposphere
3. The high number of ionized particles in the troposphere, more characteristic of this atmospheric layer than others
4. The turbulence characteristic of this atmospheric layer

3-46. What type(s) of (a) transmitting and (b) receiving antennas, respectively, are used in the process of forward propagation tropospheric scatter communications?
1. Both (a) and (b), parabolic
2. Both (a) and (b), horizontal dipole
3. (a) Vertical dipole, (b) parabolic
4. (a) Parabolic, (b) horizontal dipole

A. The scatter angle increases.

B. The scatter angle decreases.

C. The amount of received energy increases.

D. The amount of received energy decreases.

E. The amount of turbulence around the signal increases.

F. The amount of turbulence around the signal decreases.

G. The amount of turbulence, being negligible in this layer, remains the same.

List 3A.

- Use list 3A in answering question 3-47.

3-47. Which of the preceding conditions occur as a result of an increase in the height of the scatter?
1. A, D, F
2. A, D, G
3. B, C, E
4. B, C, F

3-48. What level of transmitter power and antenna sensitivity are generally used for the process of tropospheric scatter operation?
1. High-power transmitters, high-gain transmitting antennas, and very sensitive receiving antennas
2. Medium-power transmitters, medium-gain transmitting antennas, receiving antennas of moderate sensitivity
3. Low-power transmitters, medium-gain transmitting antennas, very sensitive receiving antennas
4. High-power transmitters, high-gain transmitting antennas, receiving antennas of low to moderate sensitivity

3-49. Which of the following is a problem encountered when tropo-scatter is employed?
1. Operation can be conducted effectively only from sunset until sunrise
2. In the northern hemisphere, operation can be conducted effectively only during winter months
3. The signal level is subject to rapid and continuous change because of changes in atmospheric conditions
4. Tropo-scatter is essentially short-range, and, because of phase reversals of the refracted waves, there is no way to add range by the use of signal amplifiers at additional relay stations

---

Learning Objective: Describe ionospheric layers D, E, sporadic E, and F.

To answer questions 3-50 through 3-53, select from column B the ionospheric layer to match the description shown in column A.

A. Descriptions

3-50. Composed of patches of ionized atmosphere that occur erratically and affect signals significantly

3-51. Present only during the daytime. Ionization is relatively low. Affects signal little except for absorbing energy from the passing waves

3-52. During daylight hours this layer is divided into two layers; then shortly after sunset it again becomes one layer

3-53. Present at night, but stronger during the day, and strongest at about mid-day. Of great importance to daytime transmissions up to 1,500 miles

B. Layers

1. D layer
2. E layer
3. Sporadic E
4. F layer

Learning Objective: Differentiate among various components of radio waves.

3-54. What are the two major components of a radio wave?
1. Sky wave and direct wave
2. Sky wave and ground wave
3. Space wave and ground wave
4. Space wave and surface wave

3-55. What are the two components of a space wave?
1. Direct wave and ground-reflected wave
2. Direct wave and surface wave
3. Sky wave and surface wave
4. Sky wave and ground-reflected wave

3-56. What are the two components of a ground wave?
1. Refracted wave and space wave
2. Direct wave and surface wave
3. Surface wave and sky wave
4. Surface wave and space wave

3-57. What type of wave travels in a line-of-sight path and has a range limited to the distance to the horizon plus a small distance around the curvature of the earth added by atmospheric diffraction of the wave?
1. Ground-reflected wave
2. Surface wave
3. Direct wave
4. Sky wave

3-58. What type of wave may be refracted from the ionosphere and returned to Earth far from the transmission point?
1. Ground wave
2. Space wave
3. Sky wave
4. Surface wave

3-59. What type of wave undergoes a phase reversal and can cause an undesirable cancellation of signal by arriving at the receiving antenna approximately 180° out of phase with the direct wave?
1. Ground-reflected wave
2. Surface wave
3. Sky wave
4. Ionospheric wave

Learning Objective: Define "FOT" and "MUF."

3-60. What does "FOT" mean, as defined in your textbook?
1. Fast overseas transmission, a term used to describe long-distance communications by ionospheric refraction
2. Frequency of optimum transmission, the most reliable frequency to use for transmission at a specified time
3. Flip-over transmission, descriptive of ground-reflected signals that undergo phase reversal as they are reflected
4. Fade out trouble, a term used in connection with a standard system of reporting, on a scale of 1 to 5, the degree of trouble at a specified time due to fading caused by signals arriving out of phase

3-61. Frequency tables are compiled which contain predicted maximum usable frequencies (MUFs) for every locality from which transmissions will be made. What is an MUF?
1. The maximum frequency standard Navy receivers in that locality are designed to receive
2. The maximum frequency that may be used at specified times at that locality because signals of a higher frequency are subject to penetrating the ionosphere and not returning to Earth
3. The maximum frequency that is allocated by FCC for Navy use at that locality
4. The maximum frequency that will produce a usable scatter pattern in the troposphere in that locality

---

Learning Objective: Explain the reason for multipath fading and the meaning of the term "selective fading."

3-62. Why does multipath fading occur?
1. Some of the signals are segmented when they penetrate the troposphere, refracted from the ionosphere, and then merged together, out of phase, as they return through the troposphere
2. Two or more transmitters are located very closely together, causing the paths of their signals to converge and sometimes cross, partially canceling each other out
3. Signals traveling from one atmospheric layer to another tend to change frequency slightly and are not heard well (if at all) at the receiver because they are off frequency
4. Signals from the same site go to the receiver by different paths (e.g., direct, single hop, double hop), and arrive in varying phase relationships

439

3-63. What is selective fading?

1. The condition resulting when the various components of a wide-band wave, being at different frequencies, travel different paths to the receiver and arrive with different phase relationships and different relative amplitudes
2. A term used in connection with the segments of time of day or night that fading is most likely to occur
3. The inability to receive certain frequencies with a standard Navy receiver. This is a characteristic of the hardware, and the blocks of canceled frequencies will differ from receiver to receiver
4. A flutter in the incoming signal caused by regular recurrent fading of alternate RF waves

---

Learning Objective: Name the types of periodic variations that occur in the ionosphere.

A. Changes within an individual day

B. Seasonal changes

C. Sunspot cycle variations

D. Variations due to phases of the moon

List 3B.

- Use list 3B in answering question 3-64.

3-64. Select from the preceding list the periodic variations that exist in the ionosphere.

1. A, B, C, and D
2. A, B, and C only
3. A and B only
4. B only

Learning Objective: Describe characteristics of the MF, HF, UHF, and SHF/EHF bands.

To answer questions 3-65 through 3-68, select from column B the frequency band that matches the description given in column A.

A. Descriptions

3-65. This is the principal band for ship-to-shore communications. It utilizes the ionospheric refraction for long-range communications

3-66. Diffuse reflection is quite prevalent. Much of the incident radiation is absorbed. Even raindrops can cause scattering and absorption. Satellite communication systems operate at this frequency

3-67. The Navy makes short- to moderate-range transmissions in the lower part of this band, and moderate-range transmissions in the upper part. Commercial broadcasts are transmitted at mid-band

3-68. Nearly all the energy transmitted point-to-point in this band travels in a curved path in the troposphere, extending beyond the horizon, and can go farther still by tropospheric scatter. There is some trouble with fading

B. Bands

1. MF
2. HF
3. UHF
4. SHF and EHF

Assignment 4

Basic Test Equipment; System Diagnosis and Quality Assurance

Textbook Assignment: Pages 116 - 153

Learning Objective: Describe the proper care, use, and handling of test equipment.

● Judge questions 4-1 through 4-4 as True or False, in respect to the care, use, and handling of test equipment.

4-1. Nearly all test equipment is rugged and durable and requires NO special care except to ensure that it is NOT left outside, exposed to elements of weather.

4-2. A common cause of meter damage is the selection of the improper meter range, and the subsequent attempt to measure a higher level than the meter was designed to measure.

4-3. Test sets should be stowed in a dry place, dust covers should be on, and, aboard ship, lockers containing test equipment should be padded to prevent damage which could occur when the ship rolls or pitches.

4-4. Careless stowage of cables and accessories may lead to inaccurate measurements because of resultant changes in cable characteristics, short circuits, etc.

4-5. Which of the following statements concerning the relationship between test equipment meters and magnets is correct?
1. On a weekly schedule, each meter must be "zeroed" by holding a strong magnet close to it briefly if maximum meter accuracy is to be maintained
2. On a monthly schedule, each meter must be "zeroed" by holding a strong magnet close to it briefly if maximum meter accuracy is to be maintained
3. Test equipment meters should be kept away from strong magnets
4. Magnets have no effect on test equipment magnets

Learning Objective: Identify the categories of maintenance associated with stated functions.

4-6. What is the name of the category of maintenance that includes the following actions: making routine checks to be sure the equipment is working properly; visually inspecting equipment components and wiring for damage and wear; performing periodic lubrication; and performing component adjustment?
1. Passive
2. Active
3. Preventive
4. Corrective

4-7. What is the name of the category of maintenance that includes the following actions: isolating equipment troubles; replacing defective parts; and realigning/readjusting equipment so that it will again perform properly?
1. Passive
2. Active
3. Preventive
4. Corrective

Learning Objective: Explain the reason for a difference in the amount of current before and after a cable is replaced; identify those characteristics for which a match is important between a test set and the equipment to be tested.

4-8. As RM3 Jernigan was beginning to measure the current at a certain point on a piece of radio equipment, he noticed that the insulation on the test set cable had a gash in it, exposing the bare wire. He then took a somewhat similar cable from his work drawer and replaced the defective one. The current reading he then obtained in a circuit differed from the reading shown in the technical manual, although it had checked out well the previous day. The facts given would indicate what probable reason for this deviation?

1. He has set the meter range marker incorrectly
2. He has failed to position the replacement cable correctly or tighten it securely
3. The substitution of the cable caused a mismatch of impedance between the test equipment and the equipment under test
4. The defective cable allowed an excess of current to flow and be stored in a capacitor. This current is now gradually leaving the capacitor and flowing with the normal line current

4-9. In what basic areas must consideration be given to the compatibility of the test equipment and the equipment under test?

1. Impedance matching and frequency only
2. Frequency and amplitude only
3. Impedance matching, frequency, and amplitude only
4. Impe[illegible]ce matching, frequency, amp[illegible]nd polarity

---

Learning Objective: Identify the functions of specified meter control switches.

To answer questions 4-10 through 4-13, select from column B the meter control switch to match each of the functions in column A. (Alternatives may be selected once, more than once, or NOT at all.)

A. Functions

4-10. To select various voltage or resistance scale values to be measured

4-11. Normally to turn the meter on or off

4-12. To set the meter pointer at zero, mid-scale, full-scale, or at any other value desired

4-13. To select the type of meter operation desired

B. Switches

1. Function switch
2. Range switch
3. Min/Max Variation switch
4. Zero Adj switch

Learning Objective: Identify test equipment familiarization procedures, if any, and distinguish among procedures for measuring capacitance, current, inductance, resistance, and voltage.

4-14. What type of instruction, if any, should you receive before taking measurements with a type of test set with which you are NOT familiar?

1. You should ask a nearby co-worker to tell you how to use it
2. You should take time to familiarize yourself somewhat with the set by looking at the controls and meters and reading what they say. Then, using your past experience (if any) with other test equipment, you should go ahead with your measurement
3. You should study the technical manual for this test set if it is available. If NOT, you should be instructed by your work center supervisor
4. None. You are encouraged to go ahead on your own and learn by trial and error

To answer questions 4-15 through 4-18, select from column B the type of check that matches the corresponding description in column A.

A. Descriptions

4-15. Seldom taken in preventive or corrective maintenance. Can be taken by using a test set that is intended primarily for measuring a different property. Sometimes a conversion chart is required

4-16. Very valuable in determining overall stage efficiency. Measures dielectric strength

4-17. Usually a valuable aid in locating trouble during corrective maintenance. Many maintenance handbooks contain charts which indicate the test points (usually tube sockets)

4-18. Rarely taken in preventive maintenance or testing, as unsoldering is usually required for test. Usually Ohm's Law is applied to determine the value of this property, which in most circuits is quite small

B. Types of Check

1. Capacitance check
2. Current check
3. Inductance check
4. Resistance check

Learning Objective: Identify and explain the purpose and use of various test equipments.

4-19. Most meters are designed to be able to measure more than one electrical quantity. What are such meters called?
1. Omnimeters
2. Diversimeters
3. Multimeters
4. Varimeters

4-20. When you are measuring current with an ammeter, should you connect the ammeter in series or in parallel, and what should its polarity be in relation to the direction of current flow?
1. In parallel, with the current flowing into the negative terminal
2. In parallel, with the current flowing into the positive terminal
3. In series, with the current flowing into the negative terminal
4. In series, with the current flowing into the positive terminal

4-21. If the current to be measured with a meter exceeds a very small amount, it will be necessary to use a shunt with the meter. What is a shunt?
1. A larger, more rugged meter case and dial that snaps onto the outside of the smaller meter, thereby adding to its resistance and protecting it
2. A high-value resistor (with leads) to be connected in series between the incoming current of the equipment under test and the ammeter
3. A fuse (with leads) to be connected between one of the meter leads and the incoming current circuit. If the current is above a certain level, the fuse will blow and prevent meter damage
4. A large low-resistance conductor to be connected in parallel with the meter terminals. This conductor will carry the majority of the load current

4-22. When you are measuring voltage with a voltmeter, should you connect the meter in series or in parallel, and what should its polarity be in relation to the direction of current flow?
1. In parallel, with the current flowing into the negative terminal
2. In parallel, with the current flowing into the positive terminal
3. In series, with the current flowing into the negative terminal
4. In series, with the current flowing into the positive terminal

4-23. In reference to the circuit under test, what should be the relative resistance of (a) an ammeter and (b) a voltmeter to obtain readings of the highest accuracy?
1. Both (a) and (b), small
2. (a) Small, (b) large
3. (a) Large, (b) small
4. Both (a) and (b), large

4-24. In reference to a voltmeter, what do the ratings of (a) ohms-per-volt, (b) value given as a percentage (e.g., one percent), and (c) 1V, 100V, 1000V indicate?

1. (a) Sensitivity, (b) selectivity, (c) range
2. (a) Accuracy, (b) selectivity, (c) thermal state
3. (a) Sensitivity, (b) accuracy, (c) range
4. (a) Range, (b) thermal state, (c) accuracy

● Use the following as the alternatives for questions 4-25 through 4-27. Select the response that correctly states the location of the needle on the dial of an ohmmeter under the condition given.

1. Far right end
2. Far left end
3. Center

4-25. The reading is "0."

4-26. The test leads are shorted together.

4-27. The test leads are separated from each other and NOT touching anything else.

4-28. Before you measure resistance, it is important that you calibrate (zero) the ohmmeter. How do you do this?

1. By selecting the proper range scale, placing the test probes at the test points of the circuit to be tested, and adjusting the zero-adjust rheostat to zero
2. By selecting the proper range scale, shorting the ends of the test probes together, and adjusting the zero-adjust to mid-scale so that the needle may safely go either way
3. By selecting the proper range scale, shorting the ends of the test probes together, and adjusting the zero-adjust rheostat to zero
4. By selecting the highest range scale, placing the test probes at the test points of the circuit to be tested, adjusting the zero-adjust dial to zero; then repeatedly turning to the next lower range scale and repeating the steps given, in sequence, until the calibration has been completed for all range scales

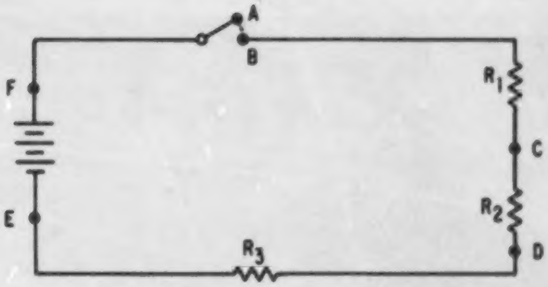


Figure 4A. - Circuit containing resistance (R_2) to be measured.

● Refer to figure 4A when answering question 4-29.

4-29. If the resistance of R_2 is to be measured with an ohmmeter, (a) in what position should the on/off switch be placed, and (b) where should the test probes be placed?

1. (a) Off, (b) at C and D
2. (a) Off, (b) at E and F
3. (a) On, (b) at C and D
4. (a) On, (b) at E and F

4-30. You have set the range scale of the ohmmeter at R x 100 and are properly measuring the resistance of a load. The meter reads 250 ohms. What is the resistance of the load?

1. 2.5 ohms
2. 250 ohms
3. 2,500 ohms
4. 25,000 ohms

4-31. For what is a megger primarily used?

1. To measure the capacitance of a circuit, and by the use of an auxiliary switch, its inductance
2. To measure the insulation resistance of conductors and RF cables and the dielectric strength of capacitors
3. To measure the voltage of a circuit at its source and also at its return to the source in order to derive a voltage efficiency rating for the circuit
4. To measure the strength and polarity of the field set up around the electrical conductors of the circuit under test

4-32. When power is being measured with a wattmeter, why is it important to adhere strictly to the "safe rating" limits for current and voltage?

1. Because if current or voltage is excessive, the meter pointer will likely hit against the upper limit of the dial and be damaged
2. Because the pointer does not give an indication to alert the user when the internal coils are overloaded even though the insulation surrounding them may be burning
3. Because, even though no damage will be done because of a safety feature in the wattmeter, a false reading will be obtained
4. Because, although the pointer gives warning by deflecting sharply to the right, internal damage is done simultaneously

4-33. There are special wattmeters available for circuits involving the higher frequencies. Why are the electrodynamic wattmeters that are used for the lower frequencies NOT suitable for use at the higher frequencies also?

1. Electrodynamic wattmeter errors increase with frequency
2. The frequency selection dial on the wattmeter does not have a setting for the higher frequencies
3. At frequencies above a certain level, the meter pointer oscillates from one end of the dial to the other
4. Meter pointer vibration increases with frequency to the point that it becomes impossible to obtain a reading

4-34. RM3 Parker is preparing to measure an unknown frequency by using a heterodyne frequency meter. Parker will match the frequency of a calibrated, high-precision oscillator to that of the unknown frequency. What indication will there be when the two frequencies match?

1. One dot of light on the screen will be superimposed on the other
2. One vertical line on the screen will be superimposed on the other
3. The two tones in the headset will achieve the same pitch, at which time a series of clicks will begin
4. The tone in the headset will decrease in pitch, and be replaced by clicks, which will then become slow or non-existent

4-35. You should NOT be in too big a hurry when beginning to use a frequency meter. Which of the following is a major reason for this?

1. You should take time to short the leads together and be sure the pointer is on zero
2. You should allow for sufficient meter warm-up time
3. You need to always check the meter with a shorting probe before using it
4. It is easy to attach the meter upside down, thus causing false readings

4-36. From where does the National Bureau of Standards broadcast its standards?

1. WWV at Beltsville, MD and WWVH at Maui, Hawaii
2. WWV at Washington, DC and WWVH at Honolulu, Hawaii
3. WWV at Washington, DC and WWVH at Maui, Hawaii
4. WWV at Denver, CO and WWVH at Honolulu, Hawaii

A. Radio propagation notices

B. Standard audio frequencies

C. Standard musical pitch

D. Standard radio frequencies

E. Standard time intervals

F. Time signals

List 4A

- Use list 4A in answering question 4-37.

4-37. Which of the technical radio services listed are provided by WWV and WWVH?

1. All except A
2. All except C
3. All except E
4. All

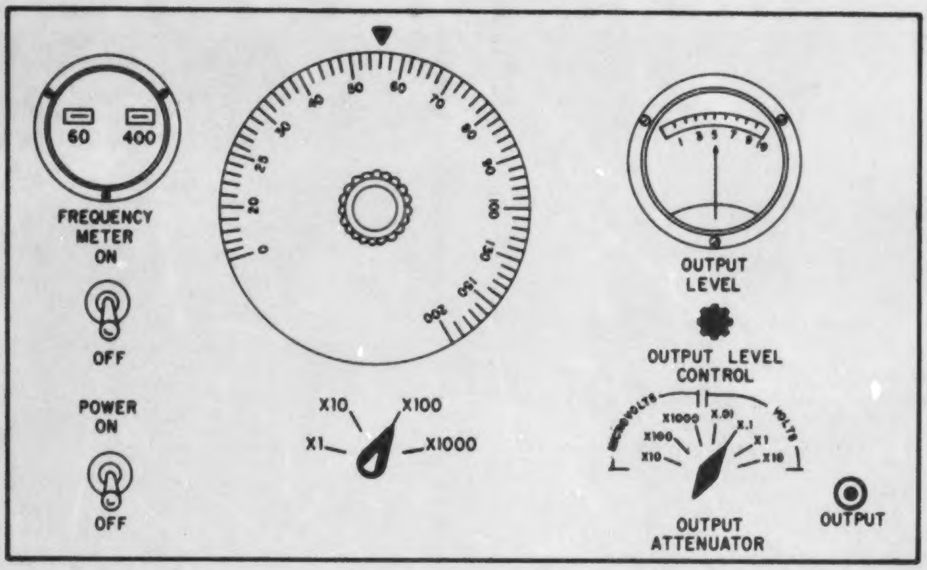

60
400
FREQUENCY METER
ON
OFF
POWER
ON
OFF
0
20
25
30
40
50
60
70
80
90
100
120
150
200
X10
X100
X1
X1000
OUTPUT LEVEL
OUTPUT LEVEL CONTROL
MICROVOLTS
VOLTS
X1000
X.01
X100
X.1
X1
X10
X10
OUTPUT ATTENUATOR
OUTPUT

Figure 4B. - Panel of audio frequency generator.

- Use figure 4B to answer question 4-38.

4-38. What are the frequency and output voltage of the audio frequency generator shown?

1. 56 Hz, 5 volts
2. 560 Hz, .5 volt
3. 5600 Hz, .5 volt
4. 5600 Hz, 5 volts

4-39. As part of checking the operation of the oscillator of an audio frequency generator at 60 Hertz, after you set the dials, you move the main tuning dial back and forth slightly while you are alert to notice when what occurs?

1. The 60-Hz reed vibrates with maximum amplitude
2. An audible tone sounds
3. A red indicator slides across the slot above "60" in the frequency meter
4. The calibration light on the panel comes on

4-40. When an AF modulation signal is fed into an RF signal generator, where is it inserted?

1. At the X-MULT jack, at the bottom front of the panel, just right of center
2. At the X200K jack, at the bottom front of the panel, about halfway between the center and right edge
3. At the EXT MOD IN jack, at the bottom right-hand corner of the front panel
4. At the X-Y jack around on the right side of the generator (not the front), near the bottom

4-41. What is the name of the very versatile piece of test equipment that gives a visual presentation of a signal on a screen, much like a television screen, showing frequency, shape, phase, amplitude, and other characteristics?

1. Oscilloscope
2. Standing wave ratio meter
3. Distortion analyzer
4. Multimeter

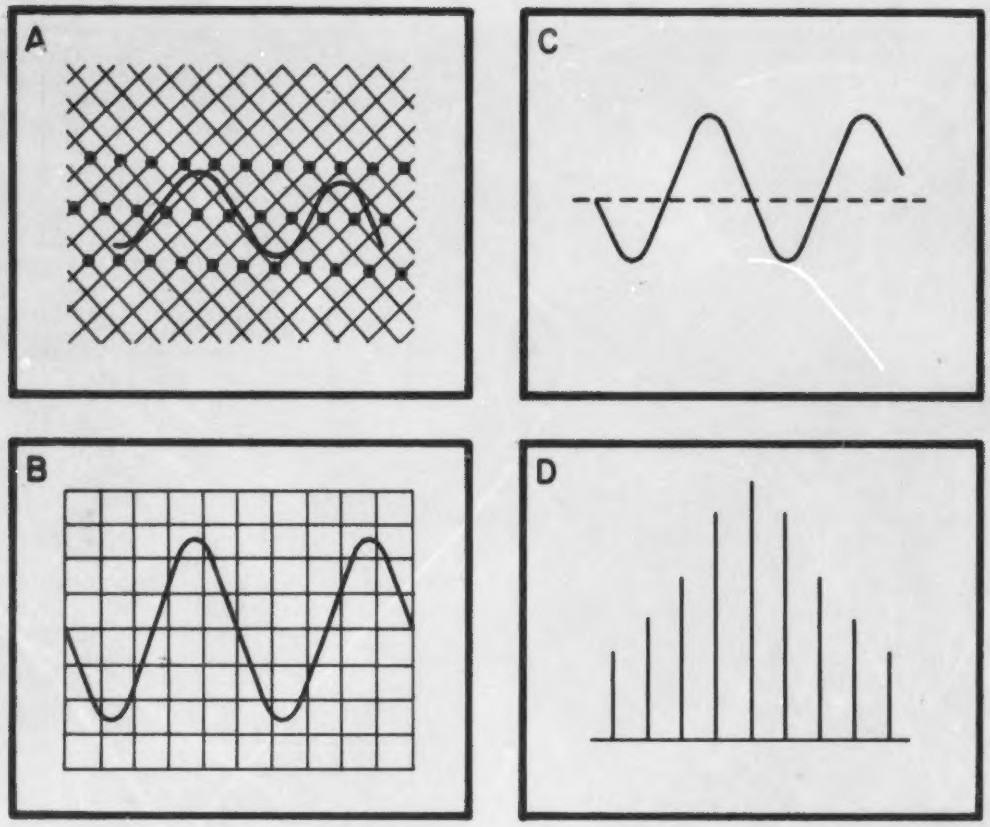


Figure 4C.

- Refer to figure 4C when answering question 4-42.

4-42. Which of the following representations is a typical spectrum analyzer CRT display?
1. A
2. B
3. C
4. D

4-43. Which of the following conditions does the emission type tube testers check primarily?
1. The condition of the cathode
2. The percentage of gas in the tube
3. The degree of leakage, if any, around the base of the tube
4. The condition of the anode

4-44. Which of the following is normally used as a means of obtaining accurate measurements of the circuit outputs when an oscilloscope is used?
1. A small, strong, lightweight nylon measuring tape which rolls tightly within its container and is kept behind a sliding door on the side of the O-scope
2. Grids scored on plates of glass or plastic that can be mounted in front of the screen
3. A pattern of four beams of light that cross the screen horizontally, vertically, and diagonally (both ways)
4. A slow scan device coupled with a timer

4-45. The spectrum analyzer presents a display from an intermediate frequency which is produced by beating the signals from what two components?
1. A superheterodyne receiver and an amplitude-modulated AF signal generator
2. A superheterodyne receiver and a frequency-modulated RF oscillator
3. A superheterodyne receiver and a mixer circuit
4. Two superheterodyne receivers, tuned to certain specifications

4-46. Which of the following conditions does the transconductance type tube tester check primarily?
1. The degree of "glow" of the tube
2. The amount of heat present at the surface of the cathode when the tube is fully warmed up
3. The ability of the tube to conduct when a series of varied inputs is applied
4. The ability of the tube to amplify under simulated circuit conditions

---

Learning Objective: State, describe, and explain some safety measures important to those who work around electrical and electronic equipment.

● Safety is everybody's business -- and everybody's responsibility! If you see an unsafe condition or practice, speak up or take action. You may save a life! Questions 4-47 through 4-62 deal with safety.

4-47. You are assigned a maintenance job involving high-voltage equipment. You attempt to find a safety observer, but are NOT able to do so. Which of the following things should you do?
1. Find a safety observer before beginning the maintenance
2. Immediately proceed cautiously with the maintenance
3. Proceed cautiously with the maintenance after notifying the communications officer
4. Proceed cautiously with the maintenance after notifying the duty officer

4-48. RM3 Suprono reported to duty; wiped the rain from his shoes and the shoulders of his shirt; unrolled the rubber mat he had bought at the mall; placed the mat on the floor in front of his rolling steel chair at his workbench; selected, among other things, the insulated molded flashlight from his toolbox; and announced that he was ready to work on the equipment. Which of the articles mentioned are electric shock hazards or unreliable articles of protection?
1. Steel chair only
2. Wet clothing and flashlight only
3. Wet clothing, nonapproved rubber mat, and steel chair
4. Wet clothing, nonapproved rubber mat, steel chair, and flashlight

4-49. With what should you remove cartridge fuses?
1. The fingers of one hand
2. The fingers of both hands
3. A pair of insulated pliers
4. A fuse puller

4-50. When maintenance is to be performed, what must be done to supply switches or cutout switches from which power could be fed to the circuit?
1. They must be secured in the OPEN position and tagged
2. They must be tagged only
3. They must be secured in the OPEN position only
4. They must be secured in the OPEN position, tagged, and guarded at all times by a safety observer

4-51. Which of the following statements regarding grounding of equipment is correct?

1. Equipment to be tested must be grounded, but test equipment need not be grounded
2. Both the equipment to be tested and the test equipment must be grounded
3. The test equipment must be grounded, but the equipment to be tested need not be grounded
4. When equipment is merely being tested, it is not required that either the equipment under test or the test equipment be grounded

4-52. When you are using test probes to check voltage in a live circuit, what is the main reason why you should use only one hand?

1. You need the other hand to hold the voltmeter level so that it will give an accurate reading
2. If both hands are in contact with the circuit, the static electricity inherent in your body will cause an incorrect reading
3. If both hands are in contact with the circuit, you make a path for current to flow from test point to test point through your body
4. You need to use the other hand to turn the controls back and forth as you watch the voltmeter dial

4-53. What is the lowest current value at which a shock normally causes paralysis of the muscles?

1. 0.001 amp
2. 0.01 amp
3. 0.1 amp
4. 1.0 amp

4-54. What is the lowest current value at which a shock is normally fatal if it lasts one second or more?

1. 0.001 amp
2. 0.01 amp
3. 0.1 amp
4. 1.0 amp

4-55. Before you make a megger test, which of the following precautions should you observe?

1. Touch the leads together and turn the crank slowly to be sure the reading approximates infinity. Although you must leave the equipment energized to check it adequately, you must exercise extreme caution
2. Touch the leads together and turn the crank slowly to be sure the reading approximates zero. Completely deenergize the equipment to be tested
3. Touch the leads together, but do not turn the crank. Ensure that the reading approximates zero. Although you must leave the equipment energized to check it adequately, you must exercise extreme caution
4. Touch the leads together, but do not turn the crank. Ensure that the reading approximates infinity. Completely deenergize the equipment to be tested

4-56. Which of the following is a safety precaution you must take if you are to conduct a megger test on components having high capacitance?

1. Discharge the components with an approved shorting probe before (but not necessarily after) making the megger test
2. Discharge the components with an approved shorting probe both before and after making the megger test
3. Discharge the components with an approved shorting probe after (but not necessarily before) making the megger test
4. Measure the capacitance with a capacitance meter before and after the megger test, and discharge if the reading exceeds the numerical value specified in the technical manual

419

4-57. Which of the following sets of instructions should you follow when handling a cathode-ray tube?

1. Handle it very carefully, carry it only by the narrow neck, and, if you must put it down, stand it on its face on a thick piece of felt, if possible
2. Handle it very carefully, carry it only by the narrow neck, and, if you must put it down, lay it on its side on a heavy piece of felt, if possible
3. Handle it very carefully, being careful not to scratch or bump it because the glass envelope contains a high vacuum and will implode if punctured
4. Handle it very carefully, being careful not to scratch or bump it because the glass envelope contains a high pressure and will explode if punctured

4-58. When you are discarding a cathode-ray tube, you should put it in an empty CRT carton and act in accordance with which of the following sets of precautions?

1. Be careful not to break off the locating pin or the tip of the glass vacuum seal; be careful not to get the toxic chemical phosphor coating on your hands or on any skin breaks
2. Carefully break off the tip of the glass vacuum seal, but do not break off the locating pin; be careful not to get the toxic chemical phosphor coating on your hands or on any skin breaks
3. Carefully break off the locating pin and the tip of the glass vacuum seal; be careful not to get the toxic chemical phosphor coating on your hands or on any skin breaks
4. Carefully break off the locating pin and the tip of the glass vacuum seal; take normal precautions not to cut yourself, but the coated glass of the CRT is of no more potential danger to you than any other sharp glass

4-59. What should you do if you observe a shipmate suffer an electric shock, lose consciousness, and continue to hold to the live conductor? (In all cases, you will remain with the victim until help arrives.)

1. First, rush to him and try to pull him free from the conductor; then administer artificial respiration, give him a stimulant, and send for the doctor or corpsman
2. First, turn off the voltage if possible. If you cannot, try to free him from the conductor, protecting yourself, meanwhile. Then see if he is breathing, loosen his clothing, keep him warm and still, administer artificial respiration if he is not breathing, and send for a doctor or corpsman
3. Call for a medical doctor or corpsman; then turn off the voltage if possible. If you cannot, try to free him from the conductor, protecting yourself, meanwhile. Loosen his clothing, and keep him warm
4. Call for two other shipmates to help you. One of you should immediately try to pull the victim free from the conductor, one should call the doctor or corpsman, and one should turn off the voltage if he can locate and gain access to the source. Then loosen the victim's clothing, cover him, see if he is breathing, and administer artificial respiration if necessary

4-60. How is it possible for a person who is conscious to sustain RF-energy burns which may result in serious consequences without realizing that this is occurring?

1. An RF-energy burn causes a cooling, rather than a heating, sensation, which the victim does not associate with an RF-energy burn
2. Preceding an RF-energy burn there is always a jolt resulting in a short period of time that all conscious thought processes are absent. The victim will never recall this particular time
3. This occurrence causes drowsiness, and the victim nearly always thinks he merely needs more sleep
4. The RF-energy heating action penetrates through tissue to the bone where there are no nerves which can alert the victim that burning is taking place

450

A. Get proper permission and authorization (from the CIC Officer and the OOD, for example)

B. Wear a rubber chest-protector

C. Ensure that the transmitter is NOT energized, and that RF energy from nearby transmitter antennas is NOT harmful

D. Procure the assistance of a person qualified in rigging

E. Ensure that a fire truck is standing by

F. Wear a safety belt and secure tools to your person with carrier lines. Secure your safety belt as soon as you reach the work area

G. Take a safety belt with you and secure tools to your person with carrier lines. Fasten the safety belt unless you can prop yourself securely, in which case you need NOT fasten it

H. Ensure good footing and grasp and hold fast

List 4B.

- Use the preceding list of safety rules in answering question 4-61.

4-61. Which rules apply when you go aloft to work on an antenna?
1. A, B, C, E, F, H
2. A, C, D, F, H
3. A, C, E, G, H
4. C, D, F, H only

4-62. Which of the following types of fire extinguishers is/are satisfactory for use on electrical fires?
1. CO_2 gas only
2. Carbon tetrachloride and CO_2 gas only
3. Carbon tetrachloride, CO_2 gas, and foam only
4. Carbon tetrachloride, CO [illegible] soda-acid, and foam

Learning Objective: Explain procedures associated with testing resistance and voltage, and interpreting an oscilloscope display.

4-63. How and with what should you make a resistance check, using point-to-point resistance charts in the equipment technical manual?
1. Using an ohmmeter, measure the d.c. resistance between specified points in the circuit and ground. The meter indicates the amount of resistance present
2. Using a test line with a light bulb (load) in the center and a test probe on each end, touch specified points of the circuit with one probe and ground with the other. The brightness of the light indicates the amount of resistance present
3. Flip the "test" switch on the panel to ON, then rotate panel adjustment knobs and record their position when the audio tone ceases (the null)
4. Flip the "test" switch on the panel to ON, then rotate the panel adjustment knobs and record their position when the dial indicates exactly zero

4-64. When the operator is making resistance checks, should the power to the equipment under test be on or off, and what should be the condition of the capacitors in the circuit?
1. Power off; capacitors left precisely as they were when the power was turned off
2. Power off; capacitors discharged
3. Power on; capacitors operating normally
4. Power on; by-pass conductors attached between large capacitors and ground

4-65. Why is it important to take voltage measurements in locating troubles or trouble symptoms?

1. Because a change in voltage causes a change in power, and power abnormality is always the basic key to troubleshooting
2. Because if an abnormal voltage can be returned to normal by adjusting resistance, it can safely be assumed that the equipment is repaired and can be relied upon to be dependable
3. Because knowledge of voltage abnormalities helps us find trouble spots, as most equipment and system troubles either result from abnormal voltages or produce abnormal voltages
4. Because, although most equipment troubles do not affect voltage, those few that do affect it ordinarily are of serious nature and need to be repaired promptly to avoid equipment damage

4-66. To avoid damage to the voltmeter and to attain high accuracy of reading, what is the procedure recommended in your textbook for setting the range on the voltmeter?

1. First set it to the highest range, then to the range that will permit close, detailed comparison with the measurement shown in the voltage chart
2. Set it only to the range that will permit close, detailed comparison with the measurement shown in the voltage chart
3. First set it to the lowest range; then to the range that will permit close, detailed comparison with the measurement shown in the voltage chart
4. Set it only to the highest range. Any other setting will permit damage to the meter

4-67. When the operator measures voltage of less than 300V, which of the following procedures should he follow before he reads the meter?

1. Turn the power on. With one hand, place the ground lead of the voltmeter to ground; with the other, touch the other lead of the voltmeter to the point to be measured
2. Turn the power off. With one hand, place the ground lead of the voltmeter to ground; with the other, touch the other lead of the voltmeter to the point to be measured
3. Turn the power on. Connect the ground lead of the voltmeter; then, using one hand (other in pocket or behind back), place the end of the test prod on the point to be measured
4. Turn the power off. Connect the ground lead of the voltmeter; then, using one hand (other in pocket or behind back), place the end of the test prod on the point to be measured

4-68. During a routine preventive maintenance check, if the operator discovers that the display of a waveform on an oscilloscope resembles the reference waveform for that test point, but shows minor distortion, which of the following actions should he take?

1. He should deenergize the equipment under test immediately before it becomes damaged, and submit a priority request for corrective maintenance
2. He should deenergize the equipment, but should submit a request for corrective maintenance
3. He should not deenergize the equipment, but should conduct waveform comparison tests on it every hour for eight hours to see if anything else develops
4. He should consider this display to be satisfactory, realizing that it is not unusual for differences in oscilloscopes, placement of the leads, etc. to cause slight variations in displays

Learning Objective: Explain how and with what to test receivers relative to noise and input and output voltages.

4-69. Noise present in a receiver can generally be attributed to what two sources?
1. Atmospheric disturbances; magnetic disturbances
2. Atmospheric disturbances; electrical components in the receiver circuits
3. Movement of the antenna during wind; vibration of the RF amplifier during operation
4. Humming of tubes; random "popping" of transistors

4-70. You insert a signal of a specified voltage into the first RF amplifier of a receiver, measure the output of the signal from this amplifier, and divide the output signal voltage by the input signal voltage. Your answer will be a measure of what characteristic of the RF amplifier?
1. Gain
2. Distortion
3. Selectivity
4. Fidelity

4-71. You inject a signal of a specified voltage from a signal generator into a dummy antenna, following prescribed steps. Then the signal goes to the receiver input stage, and you measure the receiver output signal with a voltmeter. You will have the necessary measurements to determine what characteristic of the receiver?
1. Selectivity
2. Sensitivity
3. Reliability
4. Fidelity

Learning Objective: Explain how and with what to test output power (CW and modulated).

4-72. When output power measurements are made in modulated systems, the measurement is made for normal carrier output and for peak power at what percent modulation?
1. 40%
2. 60%
3. 75%
4. 100%

4-73. What test equipment is normally used to let you know when you have the proper drive for the specified percent of modulation for output power measurement, and what will result if you exceed that drive level?
1. A voltmeter; arcing and possibly fire
2. A voltmeter; an incorrect measurement and undesired heat build-up
3. An oscilloscope; distortion and undesired shifting of the carrier
4. A wattmeter; an incorrect measurement

Learning Objective: Discuss standing-wave ratio (SWR), identify test equipment used to perform specified tests, explain why massive tube replacement is a poor procedure. (This objective is continued in Assignment 5.)

4-74. (a) Should the standing-wave ratio (SWR) be high or low, and (b) what does it indicate?
1. (a) Low, (b) the degree of precision of the frequency of the equipment as compared to a standard
2. (a) High, (b) the degree of precision of the frequency of the equipment as compared to a standard
3. (a) Low, (b) the degree to which the load and source impedances are matched
4. (a) High, (b) the degree to which the load and source impedances are matched

4-75. If the installation of a new antenna or the erection of a structure close to an antenna causes a change in antenna impedance with a resultant undesirably high SWR, what is normally done to correct this situation?
1. The transmission line is replaced
2. The antenna matching network is varied to match the new antenna characteristics
3. The antenna is replaced by an antenna with characteristics that reflect a better SWR
4. The equipment impedance is varied until the SWR is better

453

Assignment 5

System Diagnosis and Quality Assurance (Continued); Communications Organization

Textbook Assignment: Pages 153 - 183

Learning Objective: (Continued) Discuss standing-wave ratio (SWR), identify test equipment used to perform specified tests, and explain why massive tube replacement is a poor procedure.

5-1. If the SWR becomes high for NO accountable reason, usually an impedance test of transmission lines, control cables, and antennas is made. What test equipment is generally used for this test?
1. Variation analyzer
2. Oscilloscope
3. Impedance response meter
4. Megohmmeter

5-2. Which of the following are equipments used in communication checks to observe small segments of the RF spectrum or of RF oscillators?
1. Wave analyzers, distortion analyzers, or sound analyzers
2. Spectrum analyzers or pulse analyzers
3. Panoramic adapters or signal analyzers
4. Variation analyzers or bandwidth analyzers

5-3. When equipment having numerous electron tubes shows indications of a potential problem, why should a massive tube replacement effort NOT begin immediately?
1. Because misalignment would probably occur
2. Because time and effort would probably be wasted, as the equipment would probably still indicate that it had a potential problem after tube replacement
3. Because an undesirable accumulation of tubes of unknown age and condition would be built up
4. All of the above

Learning Objective: Convert ratio of power gain to gain in decibels and identify the type of equipment associated with certain sensitivity measuring processes.

5-4. If a receiver has a 1000-to-1 ratio of power gain, what is the gain in decibels?
1. 10 dB
2. 30 dB
3. 3 dB
4. 10^3 dB

In questions 5-5 through 5-7, select from column B the type of equipment associated with the sensitivity measurement process (or a part thereof) given in column A.

	A. Sensitivity Measuring Processes	B. Types of Equipment
5-5.	A carrier of 400 Hz at 30% modulation is applied, and the receiver output is adjusted for a +10 dB ratio of signal-to-noise	1. CW (A1) and facsimile (A4) receivers
5-6.	The input signal voltage is adjusted to produce a +20 dB output signal-to-noise ratio, which is maintained even though the reference level may change	2. Single sideband (SSB) receivers
5-7.	Inherent in this type of equipment is a strict requirement for a high degree of frequency stability, and the associated test equipment must be highly accurate	3. Voice-modulated (A3) receivers

5-8. What does your textbook suggest as the first step in checking the sensitivity of a frequency-shift keying (FSK) system (receiver, FSK circuitry, and teletypewriter)?

1. Check the receiver of the FSK system for CW operation and sensitivity
2. With an electronic timer, measure the time interval from the initial signal input to the teletypewriter output
3. Uncouple the teletypewriter, clean and lubricate it, and run it (separately) through the tests listed in a checklist in the technical manual
4. In sequence, insert several signals of different frequencies, as specified in the technical manual, and note the corresponding outputs from the teletypewriter

---

Learning Objective: Describe procedures and test equipment utilized to determine the reserve gain of a receiver and to determine whether the operation of an amplifier is nonstandard.

5-9. By which, if any, of the following ways can the reserve gain of a receiver be determined?

1. By finding the ratio of an inserted signal of specified strength to the resultant output signal when the receiver is set for standard gain
2. By measuring the ratio of noise output at standard gain to noise output at maximum gain (provided maximum gain does not cause an output overload)
3. By measuring the ratio of noise output at minimum gain to noise output at maximum gain (provided maximum gain does not cause an output overload)
4. None of the above

5-10. You suspect the amplification characteristics of one of the amplifiers in the receiver varies considerably from the others. Which of the following actions would best help you learn whether you are correct, and, if so, how it varies?

1. Insert signals from an FM signal generator, and display amplifier response curves from the different amplifiers
2. Insert signals of various frequencies and measure the strength and frequency of each of the output signals with a voltmeter
3. Measure the resistance across each amplifier when the circuit is operating normally
4. Measure the voltage across each amplifier when the circuit is operating normally

---

Learning Objective: Determine what portion of the receiver system is included when the term "overall selectivity" is used.

5-11. The term "overall selectivity" usually refers to the frequency selectivity of a receiver from and to what points?

1. From the input to the first amplifier to the output from the speaker or earphones only
2. From (and including) the antenna to the output from the speaker or earphones
3. From the input to the first amplifier to the input of the final detector only
4. From (and including) the antenna to the input to the final detector only

455

Learning Objective: Describe procedures for determining the squelch characteristic and for checking warm-up frequency drift.

5-12. In order to determine the squelch characteristic of a receiver, after coupling together the equipment, properly setting the degree of modulation, frequency, and RF output of the signal generator, and checking the receiver output, what should you do?

1. Gradually increase the percent of modulation until the squelch circuit operates. This percent of modulation is the squelch characteristic
2. Gradually increase the RF output of the signal generator until the squelch circuit operates. This RF output is the squelch characteristic
3. Gradually increase the frequency until the squelch circuit operates. This frequency is the squelch characteristic
4. Gradually turn the gain control on the panel of the receiver, increasing the gain until the squelch circuit operates. The voltmeter reading upon activation of the squelch circuit is the squelch characteristic

5-13. According to your textbook, to perform a warm-up frequency drift check with a heterodyne frequency meter, what should you do after you turn on the receiver and set the frequency meter to produce a 1000-Hz beat tone (in the CW mode)?

1. As the receiver drifts, readjust the frequency meter to produce a 1000-Hz beat tone. The frequency drift is indicated by the difference between the original and final frequency meter setting after the receiver frequency stabilizes
2. After the receiver frequency stabilizes, measure the difference in frequency between this receiver and a second receiver, set at the original frequency of the first receiver
3. Compute the percentage and polarity of voltage change of the receiver before and after drift
4. Compare readings of spectrum analyzer tests conducted before and after drift

Learning Objective: Identify a problem condition caused by dust on the conductors in a circuit.

5-14. A collection of dust on the insulation of the conductors in a circuit invites what condition(s)?

1. Decreased resistance in the insulation caused by the absorption of moisture by the dust; flashing of electrical energy from one component to another
2. Increased resistance in the insulation resulting in increased current flow and heat build-up as the circuit attempts to normalize
3. Increased resistance in the insulation caused by the increased diameter of insulation plus dust; flashing of electrical energy from one component to another
4. Varying resistance in the insulation (increased in some areas, decreased in some areas, caused by varying degrees of moisture) resulting in fluctuating current

Learning Objective: Explain procedures for measuring transmitter frequency and transmitter output power.

5-15. In the MF to VHF range in communications, what is normally the way to find the power output of a transmitter?

1. Measuring the current and voltage and applying a formula
2. Measuring the current and resistance and applying a formula
3. Using the "lamp-load" method
4. Reading the front panel meters of the equipment and applying a formula, if required

5-16. Identify an action to be taken in each of two methods of measuring transmitter frequency, as described in your textbook.

1. (Method 1) Inserting the outputs of a standard frequency generator and a transmitter into a dummy antenna, and coupling this antenna output to an oscilloscope; (method 2) "beating" the transmitter frequency against the output signal of a heterodyne frequency meter
2. (Method 1) Inserting the output of a standard frequency generator into a transmitter; (method 2) "beating" the transmitter frequency against the output signal of a heterodyne frequency meter
3. (Method 1) Inserting the output from a transmitter into a standard frequency generator; (method 2) inserting the output of a transmitter into a spectrum analyzer
4. (Method 1) Inserting the output from a heterodyne frequency meter into a transmitter; (method 2) "beating" the output of the transmitter with a signal of preselected frequency set into a standard frequency generator

5-17. Which of the following are used in measuring transmitter power output by the lamp-load method?

1. An incandescent lamp, an illumination meter, a variable power source, and an ohmmeter
2. A series of lamps, a rheostat, a steady power source, and an ohmmeter
3. A series of lamps, a mirror, an illumination meter, a steady power source, and a wattmeter
4. A series of lamps, an illumination meter, a variable power source, and a wattmeter

Learning Objective: Identify a problem existent in an RF amplifier and explain procedures taken to overcome the problem of degenerative feedback.

5-18. Every RF amplifier tube, including those in transmitters, has an inherent problem. What is it?

1. Cathode glow
2. Plate saturation
3. Interelectrode capacitance
4. Grid locking

5-19. What is the name given to the procedure used to eliminate or reduce the effectiveness- and efficiency-robbing effects of degenerative feedback in an RF amplifier?

1. Debilitation
2. Negation
3. Neutralization
4. Tubular suppression

Learning Objective: State the names of the type impulses associated with the perforation on paper tape, and name and explain the distinctions between the types of wire teletypewriter circuits.

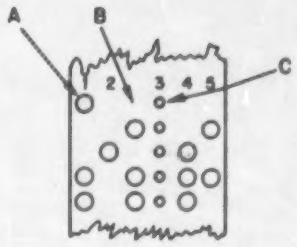


Figure 5A.

● Use figure 5A in answering question 5-20.

5-20. Identify the type impulse, if any, associated with the hole or lack of a hole in the top row of perforations in the perforated tape shown.

1. A, Spacing impulse; B, marking impulse; C, none (sprocket hole)
2. A, Marking impulse; B, spacing impulse; C, none (sprocket hole)
3. A, Excitation impulse; B, dormant impulse; C, spacing impulse
4. A, Active impulse; B, passive impulse; C, check bit impulse

5-21. What are the two general types of wire teletypewriter circuits, and what distinguishes the usage of one from the other?

1. Manned, used for circuits actively manned by personnel; phantom, used for circuits that are completely automated
2. Direct, used for direct operator-to-operator transmissions; phase-delay, used in transmissions utilizing reperforators
3. Limited signal, used for shorter distances; scatter, used for long and medium distances on landlines
4. D.c., used for shorter distances; carrier, used for long and medium distances on landlines

---

Learning Objective: Explain the reason for multiple antennas at sites receiving HF communications, and state the name of the device used to extend a circuit by receiving signals and sending them out again with increased power.

5-22. At stations receiving HF communications transmitted by sky waves, there may be two or more receiving locations separated by several wavelengths or there may be more than one antenna, either one vertical and one horizontal or differently oriented horizontal antennas. What is the usual reason for this?

1. To enable them to receive information from more than one transmitting station at the same time
2. To enable them to send replies, as well as receive transmissions
3. To compensate for transmission impairment
4. To enable them to receive both the high and low end of the HF band simultaneously

5-23. Usually, circuits are extended by inserting receiving and retransmitting equipment prior to the limiting length of a teletypewriter circuit to give the signals additional range. What is the name of this receiving and retransmitting device?

1. Super-echo
2. Repeater
3. Retransmitter
4. Piggyback transmitter

Learning Objective: Describe how to insert test signals into the teletypewriter equipment, identify the two letters used for testing teletypewriters, and describe the method of determining the high and low range extremes of a teletypewriter.

5-24. You are beginning to test the performance of the teletypewriter equipment and you want to observe its operation for test purposes. How should the signals to activate the equipment for this test be inserted?

1. You should insert the signals by means of the keyboard
2. Someone else should insert the signals by means of the keyboard while you observe
3. The signals should be inserted by means of a test tape patched into the test channel
4. You should conduct all of your test while the equipment is transmitting actual data in its normal way

5-25. The range-finder of the teletypewriter is set to the midpoint of the determined high and low range extremes of the individual equipment. How should you determine these extremes?

1. Press the "lower range" button, read the meter; press the "upper range" button, read the meter
2. Turn the "lower range" knob lower until the light under the knob flickers, read the meter; turn the "upper range" knob higher until the light under the knob flickers, read the meter
3. While alternately inserting the test letters, turn the range selector down (for low end) or up (for high end) until the "out of range" light comes on; read the meter
4. While alternately inserting the test letters, turn the range selector down, (for low end) or up (for high end) until printing errors occur; read the meter

5-26. What two letters are frequently typed alternately on a teletypewriter to test it?
1. W and Z
2. R and Y
3. H and V
4. F and S

Learning Objective: Distinguish among various types of teletypewriter signal distortion; state the normal way of calculating the degree of bias.

- Refer to figure 5B in answering questions 5-27 through 5-29.

5-27. What type of teletypewriter signal distortion is represented in waveform A?
1. End distortion
2. Bias distortion
3. Characteristic distortion
4. Fortuitous distortion

5-28. What type of teletypewriter signal distortion is represented in waveform B?
1. Characteristic distortion
2. Bias distortion
3. End distortion
4. Fortuitous distortion

5-29. What type of teletypewriter signal distortion is represented in waveform C?
1. Characteristic distortion
2. Bias distortion
3. End distortion
4. Fortuitous distortion

5-30. What is the usual method of calculating the percentage of bias distortion?
1. The ratio of the normal length of the mark or space to its present length
2. The ratio of the normal length of the mark or space to the amount it has been lengthened or shortened
3. The ratio of mark element to space element
4. The ratio of space element to mark element

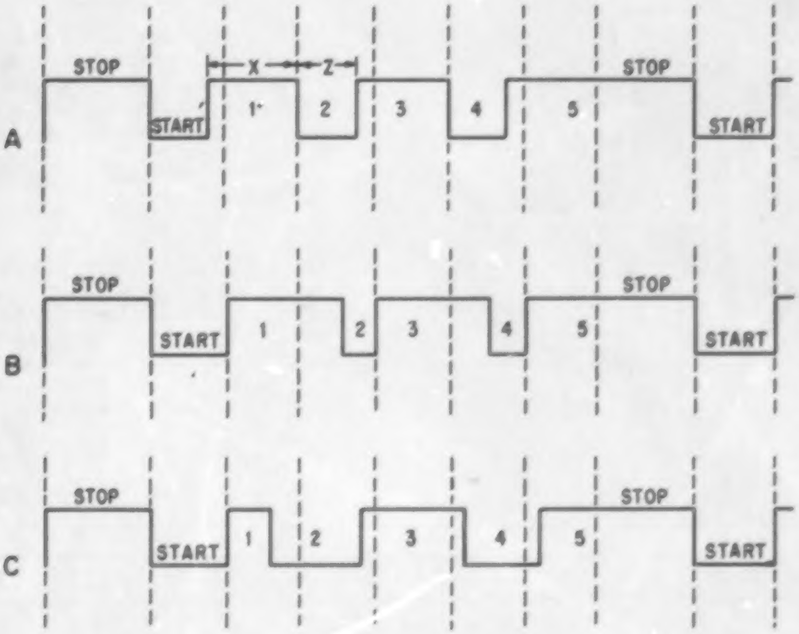


Figure 5B.

In questions 5-31 through 5-34, select from column B the type of distortion associated with the causes given in column A.

A. Causes of Distortion

5-31. May be caused by fading, multipath transmissions, atmospheric noise, lightning, and many other random disturbances

5-32. Caused by a detuned receiver or a drifting transmitter or receiver

5-33. Caused by changing current when the interval between the mark and space is too short to allow for the change of the current

5-34. Usually caused by maladjusted or dirty contacts

B. Types of Distortion

1. Bias
2. Equipment characteristic
3. Fortuitous
4. Line characteristic

5-35. Which of the following descriptions correctly points out the difference between bias and speed distortion?
1. The mark is the same length as the space in speed distortion, but not in bias. The total length of mark and space is standard in bias distortion, but not in speed
2. The mark is the same length as the space in bias distortion, but not in speed. The total length of mark and space is standard in speed distortion, but not in bias
3. The mark is the same length as the space in both bias and speed. The total length is longer than standard in bias, and shorter than standard in speed
4. The mark is longer than the space in bias, but shorter than the space in speed. The total length, however, is standard in both bias and speed

---

Learning Objective: Identify terms connected with, and give general, basic descriptions of some of the elements of signal propagation.

5-36. What is the term used for the process in which several signals are combined into one signal, transmitted from one terminal to another, and then broken down into the original signals?
1. Varityping
2. Diversi-typing
3. Multiplexing
4. Simplexing

5-37. The use of a frequency at which of the following locations on the band will sometimes offset the effects of scattered reflections of multipath propagation on MUX signals?
1. Near the minimum usable frequency
2. Near the maximum usable frequency
3. Near the midpoint of the band
4. Two-thirds of the distance up the band

5-38. In nonsynchronous cryptographic operation, what verification check helps ensure that the entire message is received or alerts personnel if it is NOT?

1. The same number of teletypewriter characters must be received as sent in order for the equipment to remain in the set or operable condition
2. The same number of teletypewriter characters must be received as sent or red lights flash at both the transmitting and receiving equipment
3. The same number of teletypewriter characters must be received as sent or buzzers sound at both the transmitting and receiving equipment
4. Each of the nonsynchronous equipments is kept in phase by its own frequency standard, rather than by character receipt count. Equipment tests are conducted to verify satisfactory operation

5-39. In synchronous cryptographic operation, what verification check helps ensure that the entire message is received, or alerts personnel if it is NOT?

1. The same number of teletypewriter characters must be received as sent in order for the equipment to remain in the set or operable condition
2. The same number of teletypewriter characters must be received as sent or red lights flash at both the transmitting and receiving equipment
3. The same number of teletypewriter characters must be received as sent or buzzers sound at both the transmitting and receiving equipment
4. Each of the synchronous equipments is kept in phase by its own frequency standard, rather than by character receipt count. Equipment tests are conducted to verify satisfactory operation

---

Learning Objective: Briefly describe and explain the problem of mutual interference in a unit containing multiple transmitters and receivers and methods of decreasing the effects of the problem.

5-40. On which of the following frequencies may the signal of an HF transmitter located close to several other transmitters and receivers cause interference?

1. At the frequency of its carrier only
2. At the frequency of its carrier and at twice that frequency only
3. At various frequencies within the HF range only
4. At various frequencies inside and outside of the HF range

5-41. Which of the following statements correctly states the effect, if any, that separating receiving and transmitting antennas normally has on the problem of interference?

1. Much of the interference disappears
2. There is about the same amount of interference, but it occurs at different frequencies
3. The interference at frequencies higher than double that of the signal is eliminated, but other interference remains as before
4. There is no change to the interference pattern

5-42. One way to partially isolate antennas from each other aboard ship or ashore is by making use of the structures or natural contours of the area. What is the term for this type of radiation blocking?

1. Radiation shielding
2. Terrain shielding
3. Contour blocking
4. Configuration blocking

5-43. In order to prevent the reradiation of spurious harmonics from guy wires which support antennas, what precautions should be taken with guy wires?

1. They should be insulated at the ends and should be exactly the length associated with one wavelength at the normal operating frequency of the associated transmitter only
2. They should be grounded and should be exactly the length associated with one wavelength at the normal operating frequency
3. They should be insulated at the ends and should be exactly the length or twice the length associated with one wavelength at the normal operating frequency
4. They should be in insulated sections, in lengths not related to the harmonics of the normal operating frequency

5-44. Your textbook lists some ways in which cross modulation can be reduced. What are they?
1. Using only vertical antennas, and separating transmitting antennas from receiving antennas and from each other
2. Using only horizontal antennas, separating transmitting antennas from each other, and separating receiving antennas from each other
3. Reorienting transmitting antennas to take advantage of their directional characteristics, separating transmitting antennas from each other and from receiving antennas, and separating receiving antennas from each other
4. Reorienting transmitting antennas to take advantage of their directional characteristics, separating transmitting antennas from receiving antennas, and grouping receiving and transmitting antennas together, using the same antenna for multiple receivers or transmitters whenever possible

5-45. Which of the following is a device that is often used to reduce the effect of local oscillator radiation?
1. An isolation pack
2. A multicoupler
3. An ordinary metal box
4. A bandpass duo-filter

5-46. What test instrument, used for checking for transmitter radiation, gives a visual indication of existing sidebands or interference around a carrier?
1. A wave analyzer
2. A panoramic adapter
3. A distortion analyzer
4. A pulse analyzer

● Questions 5-47 and 5-48, on the subject of shielding, are to be judged True or False.

5-47. If a metal box, used within a transmitter to shield components, has even a few 3/16"-diameter ventilation holes in it, there is so much RF energy leakage that the shield is virtually useless.

5-48. Although shielded wires (wires with a braid inside the outer jacket) are sometimes found in older transmitters, it is now recommended that they NOT be used in transmitters because they create excess radiation.

Learning Objective: Describe the method of determining the overall field strength estimate.

5-49. At how many and what points on the antenna should you take the field strength measurements to be averaged for estimated overall field strength?
1. Four -- front, back, and two sides
2. Two -- front and back at exactly the antenna midpoint
3. Six -- front and back at the following locations: adjacent to transmitter, midpoint, and at the extreme end of the antenna
4. Four -- front side adjacent to the transmitter, front side at the farthest point from the transmitter, and front and back at the midpoint

---

Learning Objective: Describe and explain some of the minor maintenance procedures relative to single-sideband equipment.

5-50. Why is it so important that the frequency adjustment of single sideband suppressed carrier (SSSC) equipment be extremely accurate?
1. Because tolerances set by FCC are stricter for SSSC than other types of equipment
2. Because if the frequency of the received carrier does not exactly match that of the local oscillator of the receiver, the system goes into "reset" condition and remains inoperable until an adjustment is made
3. Because the carrier, having been suppressed (not transmitted) and then reinserted at the receiver, must be at precisely the original frequency for the demodulation process to work properly
4. Because of the high number of SSSC equipments in use by the Navy and the consequent small allotment of the frequency spectrum assigned to each

5-51. When checks show that the carrier oscillator is out of tolerance, what should the first step be in seeking to correct the problem?

1. Inspection and testing of the vacuum tubes
2. Adjustment of the oscillator frequency
3. Checking and adjustment of the regulated voltage applied to the circuit
4. Checking and adjustment of the output signal voltage

5-52. In the adjustment of a balanced modulator, after some other checks are made, a test tone is inserted into the SSB exciter circuit, the output of which goes to an AM receiver. What should you do then, following step-by-step procedures contained in the equipment technical manual?

1. Adjust the balance control for minimum tone output from the receiver
2. Adjust the balance control for maximum tone output from the receiver
3. Adjust the balance control to achieve a certain meter reading as designated in the technical manual
4. Adjust the balance control until a series of clicks is heard from the receiver

5-53. What is normally the right action for an operator to take if he has reason to believe that the sideband filters of an SSB transmitter are NOT achieving their purpose?

1. If they are mechanical filters, report them; if crystal filters, adjust them
2. If they are mechanical filters, replace them; if crystal filters, adjust them
3. Whether they are mechanical or crystal filters, adjust them
4. Whether they are mechanical or crystal filters, replace them

---

Learning Objective: Describe and explain procedures involved in the "two-tone" test, equipment used for the measurement of peak envelope power and peak sideband power, and the function of a transmitter monitor panel.

5-54. What should be the frequency and amplitude relationship of the two tones applied to the input of the SSB transmitter for the "two-tone" test?

1. Equality in amplitude, difference in frequency of about 1 Hz
2. Equality in amplitude, difference in frequency of about 1000 Hz
3. Difference in amplitude of 25%, difference in frequency of about 100 Hz
4. Difference in amplitude of 50%, difference in frequency of about 100 Hz

5-55. The measurements of peak envelope power (PEP) and peak sideband power (PSP) are both made using the two-tone system, and are quite similar. What testing equipment usually gives the results of these tests?

1. Spectrum analyzer or voltmeter
2. Oscilloscope or voltmeter
3. Spectrum analyzer or oscilloscope
4. Panoramic adapter or voltmeter

5-56. What is the function of a transmitter monitor panel or unit?

1. To serve as a receiver for the transmitter in use so that operators can hear and quality-control the output of the transmitter
2. To display a light and ring a bell any time the transmitter fails or misfunctions
3. To switch the transmitter to d.c. power in case the a.c. power fails
4. To sample voltages or current at various places in the transmitter as a quality check on the proper operation of particular circuits

---

Learning Objective: State the basic capability of an analog computer, the names of the basic sections of a digital computer, and the function of a "marginal checking" circuit.

5-57. What are the basic sections of a digital computer?

1. Input, control, memory, arithmetic, storage
2. Input/output, control, memory, add/subtract, multiply/divide
3. Input/output, control, memory, arithmetic, verification
4. Input, control, memory, arithmetic, output

463

5-58. What is the basic capability of the analog computer which enables it to perform the various functions for which it is utilized?
1. Converting voltage and current values into digital form and converting digital data into voltages or currents to operate controls and indications
2. Converting voltage (but not current) into digital form and converting digital data into voltages to be used as input to control and indication circuits
3. Converting current (but not voltage) into digital form and converting digital data into currents to operate controls and indications
4. Performing the process known as "repeated addition."

5-59. What function does a "marginal checking" circuit in a digital computer perform?
1. To check voltage input to and output from individual circuits to ensure that they are within tolerance
2. To check current and voltage at various specific checkpoints to ensure that they are within tolerance
3. To detect frequency drift, and display a warning if any output signal frequency drifts near the limit set by FCC
4. To detect aging of parts before failure occurs

Learning Objective: State the names of various types of trouble source checks, and distinguish among three classes of maintenance programs.

5-60. What are the names of the various diagnostic program area checks used in locating sources of equipment trouble?
1. Increasing area, decreasing area, overlapping area, square search
2. Increasing area, decreasing area, overlapping area, large area
3. Increasing area, decreasing area, Venn intersect search, vector search
4. Increasing area, decreasing area, Venn intersect search, spiral search

In questions 5-61 through 5-63, select from column B the class of maintenance program associated with the purpose for which it is used, as listed in column A.

A. Purposes

5-61. To detect the existence of errors

5-62. To locate the circuits in which malfunctions originate

5-63. To serve as an aid for operational and maintenance programming procedures, to print out information from storage, and to transfer maintenance programs into memory

B. Classes of Program

1. Diagnostic
2. Reliability
3. Utility

Learning Objective: Determine the contents of a memory location by analyzing the input of the computer.

5-64. The memory of a computer has been cleared, and the computer has been instructed to read a group of cards and perform a cumulative add function, storing and adding to the subtotal in memory. It inputs cards containing the following data/instructions: 1, 2, HALT, 3, 4, 5, 6, CLEAR MEMORY. What value will then be in the memory?
1. 21
2. 18
3. 3
4. 0

Learning Objective: Explain the importance of correct usage of panel controls; state practices which will help you benefit from making tests at various control settings.

5-65. For which of the following reasons should you be knowledgeable of the correct usage of front panel controls and attentive as you operate them?
1. Because if you use and observe them correctly, you may discover potential trouble in its early stages
2. Because if you operate them incorrectly, your deductions about the cause or location of the problem are less likely to be accurate
3. Because if you operate them incorrectly, you may damage the equipment
4. All of the above

5-66. What should you do to help you retain and compare the results of tests taken at various control settings?
1. Notice exactly how the controls were set each time and make a special effort to remember the settings, results, and other pertinent facts
2. Record carefully the settings, results, and other pertinent facts
3. Make marks on the equipment to show what the settings were, and remember the results and other pertinent facts
4. Have an assistant observe the test and help you remember the settings, results, and other pertinent facts

Learning Objective: State the basic requirements of a good telecommunications system.

5-67. What are three basic requirements of a good telecommunications system?
1. It must be reliable, secure, and rapid
2. It must be reliable, simple, and rapid
3. It must be controlled, secure, and dependable
4. It must be easy, secure, and rapid

Learning Objective: Identify the source of direction and management of the Naval Telecommunications System (NTS) and the basic scope of the NTS and the Defense Communications System (DCS) relative to the Navy.

5-68. Who is responsible for directing the operations and controlling the management of the elements of the NTS?
1. Commander, Naval Support Force
2. Commander, Naval Telecommunications Command Headquarters
3. Director, Federal Communications Commission
4. Director, Command and Control Support

5-69. What is the primary distinction, insofar as area of coverage is concerned, between the Naval Telecommunications System and the Defense Communications System relative to the Navy?
1. The NTS facilities are fleet-associated, and the Navy DCS units are primarily shore facilities
2. The Navy DCS units are fleet-associated, and the NTS facilities are primarily shore facilities
3. Navy teletypewriter communications is within the realm of the NTS; Navy communications by any other means is under the cognizance of the DCS
4. Navy teletypewriter communications is within the realm of the DCS; Navy communications by any other means is under the cognizance of the NTS

Learning Objective: Demonstrate a basic familiarity with OPORDERS.

5-70. Which of the following statements concerning OPORDERS is correct?

1. The commanding officer of a ship receives OPORDERS from the applicable fleet commander in chief, and must always take action on them in their entirety
2. The commanding officer of a ship receives OPORDERS from the applicable fleet commander in chief, and must select and take action on those parts of the OPORDER that apply to him
3. The commanding officer of a ship does not receive OPORDERS, as these are handled at a higher echelon, and any necessary orders are excerpted and transmitted to him
4. OPORDERS are originated by individual ship commanders, and publicized to the staff and crew of his ship for compliance

Learning Objective: Match the names and functions of elements of NTS.

In questions 5-71 through 5-74, match the elements in column B with their descriptions or characteristics in column A.

A. Characteristics

5-71. Classified as either a transmitting or a receiving station, and suffixed, therefore, by "T," or "R." May be located a great distance from the larger element of which it is a component

5-72. NOT a part of the basic communication structure, but, rather, usually created to satisfy a special need in support of a particular mission or function

5-73. A telecommunications facility that is assigned a limited or specialized mission. Its personnel and facilities are somewhat limited

5-74. Has a primary responsibility for communication facilities and equipment to provide fleet support and fixed communication service, and to interface with other communication units

B. Elements

1. Naval Communications Stations (NAVCOMMSTAs)
2. Naval Communication Units (NAVCOMMUs)
3. Naval Radio Stations (NAVRADSTAs)
4. Naval Communications Technical Groups (NAVCOMMTECHGRUs)

Assignment 6

Communications Organization (Continued); Communications Security

Textbook Assignment: Pages 183 - 204

Learning Objective: Give brief, general descriptions of some of the facilities, functions, and organization of the Defense Communications Agency (DCA).

● Judge whether questions 6-1 through 6-4, relative to the DCS and the Defense Communications Agency (DCA), are True or False.

6-1. DCS circuits are government-owned or leased and are point-to-point circuits that are long-haul and world-wide.

6-2. The DCS exists to support the Navy, Army, Air Force, and other Department of Defense activities, and it combines elements from the three military services into a single communications system.

6-3. It is important that each message remains within the same system (NTS or DCS) in which it originated until it reaches its destination.

6-4. The DCA, under the management of a general or flag rank officer, exercises operational control over the DCS.

Learning Objective: Identify the locations of operational centers and organization of Area Communications Operations Centers (ACOCs).

6-5. Where is the focal point for worldwide operational centers of the DCA?
1. DCA Operations Center, Naples, Italy
2. DCA Operations Center, Guam
3. DCA Operations Center, Washington, D.C.
4. DCA Operations Center, Norfolk, Va.

6-6. What is the name of the centers which are subordinate to the ACOCs?
1. Field Communications Operations Centers (FCOCs)
2. Limited Communications Operations Centers (LCOCs)
3. District Communications Operations Centers (DCOCs)
4. Regional Communications Operations Centers (RCOCs)

Learning Objective: Briefly and generally describe the organization of Naval Communications Areas (NAVCOMMAREAs).

6-7. Into how many Naval Communications Areas is the world divided?
1. Five
2. Six
3. Three
4. Four

6-8. What is the name of the organization within each Naval Communications Area that exercises coordination and control of all naval communications system fleet broadcasts, ship-to-ship, air-ground, and other tactical circuits?
1. Naval Communication Area Master Station
2. Naval Telecommunications Center/Message Center
3. Technical Control Facility
4. Naval Liaison and Control Facility

Learning Objective: Match organizational segments of NAVCOMMSTAs/NAVCOMMUs with their descriptions or characteristics.

A. Naval Telecommunications Center/Message Center (NTCC)
B. Fleet Center
C. Technical Control Facility
D. Cryptographic Center
E. Navy Commercial Refile Facility
F. Receiver Site
G. Transmitter Site

List 6A.

● In answering questions 6-9 through 6-15, use the preceding list of organizational segments which are included at various NAVCOMMSTAs/NAVCOMMUs, according to the existing need. (In this group of questions, use each organizational segment once.)

6-9. Which organizational segment receives radio frequency energy and converts it to signals which are routed to the Technical Control Facility for further processing, and is responsible for receiver tuning, DC/Audio patch manipulation, quality monitoring of received signals, and antenna control?
1. D
2. E
3. F
4. G

6-10. Which organizational segment is NOT a physical part of a NAVCOMMSTA or NAVCOMMU, but serves a need by providing a message service, either ashore or afloat, where there is a need for such service because of a heavy volume of messages?
1. A
2. B
3. C
4. D

6-11. Which organizational segment provides interface between U.S. Government telecommunications systems and commercial systems (domestic, foreign, or international)?
1. A
2. C
3. E
4. G

6-12. Which organizational segment is responsible for message processing and accountability for Top Secret message traffic, provides an off-line crypto service, and assigns routing of encrypted traffic within the command?
1. A
2. C
3. D
4. F

6-13. Which organizational segment receives analog or digital data from the Technical Control Facility and radiates it in the form of radio frequency energy; and is responsible for transmitter tuning, DC/Audio patch panel manipulation, quality monitoring of transmitted signals, and antenna switching?
1. C
2. E
3. F
4. G

6-14. Which organizational segment provides interface between shore and afloat communication systems, utilizing ship-shore, air-ground, and electronic courier circuits, among others?
1. A
2. B
3. C
4. D

6-15. Which organizational segment is the core or focal point of the communications department ashore, from which all inter-patching among the various divisions takes place?
1. A
2. B
3. C
4. E

Learning Objective: Briefly and generally describe shipboard organization and functions relative to communications.

6-16. In ships that do NOT have a communications department, to what department are communications personnel assigned?
1. Administration
2. Security
3. Operations
4. Supply

In questions 6-17 through 6-20, select from column B the shipboard operational organization billets that are described in column A.

A. Descriptions

6-17. Responsible to the communications officer for maintaining optimum utilization of a good, effective communication system. Responsible for compliance with directives and for accurate and rapid handling of traffic within the communication organization of the ship

6-18. Responsible to the CWO and SWS for supervising message processing and circuit operation. Directly supervises all Radiomen on watch in the message processing area

6-19. Responsible to the CWO for all communications. Examines operational logs and monitors equipment alignment and operation. Endeavors to prevent or eliminate backlogs of messages

6-20. Ensures the use of monitoring and quality control on all operating communications systems. Also maintains the status board which displays information relative to all equipment, nets, and circuits in use

B. Billets

1. Communication watch officer (CWO)
2. Senior watch supervisor (SWS)
3. Main communication supervisor
4. Technical control supervisor

A. Administration officer
B. Commanding officer
C. Executive officer
D. Communication officer
E. Radio officer
F. Security officer

List 6B

Use list 6B in answering questions 6-21 through 6-23. These questions relate to responsibilities/duties on a ship which has a separate officer assigned to each of the billets shown. Select the officer who has the responsibility or duty described in the question.

6-21. Full responsibility for the internal handling of message traffic within the ship.
1. A
2. B
3. C
4. E

6-22. Responsibility for being cognizant of all communication annexes to Operation Plans affecting the mission of the ship in order to advise the commanding officer in respect to them.
1. A
2. D
3. E
4. F

6-23. Preparation and maintenance of the watch, quarter, and station bill.
1. A
2. D
3. E
4. F

Learning Objective: State which portion of an OPORDER or related attachment or publication is of particular benefit to Radiomen.

6-24. If you, as a Radioman, want to familarize yourself with the identification of the circuits, equipment, frequencies, etc. of direct concern to a particular operation, where should you look?
1. In the body of the applicable operation order, in the paragraph dealing with communications
2. In the communication annex to the applicable operation order, or in a separately-promulgated communication operation plan (ComOpPlan)
3. In addendum 23-C of the applicable operations order (OpOrder, Add. 23-C)
4. In supplement C of the applicable operations order (OpOrder, Supp. C)

Learning Objective: Describe, in general, the organization, functions, operation, and tools of the Standard Navy Maintenance and Material Management (3-M) System.

6-25. What is the name of the area of the 3-M system that deals with planning, scheduling, and controlling preventive maintenance in order to sustain the performance capability of the equipment?
1. The Planned Maintenance System (PMS)
2. The Preventive Maintenance Quality Control System (PMQCS)
3. The Preventive Maintenance Inspection System (PMIS)
4. The Scheduled Preventive Maintenance System (SPMS)

6-26. What are the basic tools of the 3-M system?
1. The Quarterly Schedule, the Monthly Schedule, the Weekly Schedule, Maintenance Requirement Cards (MRCs)
2. The Cycle Schedule, the Quarterly Schedule, the Monthly Schedule, the Weekly Schedule
3. The Semiannual Schedule, the Monthly Schedule, the Weekly Schedule, Maintenance Requirement Cards (MRCs)
4. The Cycle Schedule, the Quarterly Schedule, the Weekly Schedule, Maintenance Requirement Cards (MRCs)

6-27. What are Maintenance Requirement Cards?
1. Cards used to assign preventive maintenance tasks to specific individuals by date, and to record signatures, completion dates, and annotations as to any peculiarities found while performing the work
2. Cards on which are listed the enlisted rate, time, tools, parts, and materials required to perform each applicable preventive maintenance task, as well as procedures and safety precautions to take
3. Cards on which are listed the preventive maintenance tasks for the current week and the following week. These cards are inserted in the Maintenance Control Board, and kept up to date by the department head
4. Cards on which are listed any required maintenance tasks that are outside the scope of assigned personnel. These cards will be used as source documents for requesting outside assistance

6-28. What is the Maintenance Data Collection System (MDCS)?
1. A system of documenting results of daily equipment inspections and of estimated and actual expenditures of man-hours and material relative to preventive and corrective maintenance
2. A system of recording results of equipment inventories, condition of each piece of equipment, and amount of maintenance-related down time it has had, if any, during the current quarter
3. A system of documenting man-hours expended, material expended, and equipment downtime in connection with corrective maintenance
4. A system of documenting man-hours expended, material expended, and equipment downtime in connection with preventive maintenance

6-29. For what should a Work Request be used?
1. To request outside assistance when the maintenance action is outside the scope of assigned personnel
2. To charge the maintenance officer with the responsibility for accomplishing specific maintenance tasks
3. To serve as a source document for posting the task to the Maintenance Control Board, which will also display a deadline date by which time the ship's maintenance personnel must have accomplished the task
4. To assign tasks to each of the maintenance personnel

6-30. Where are the spare parts allowance lists found?
1. In the Consolidated Shore Allowance List (COSAL) (shore activities), and the Electronics Repair Parts Allowance List (ERPAL) (shipboard)
2. In the Consolidated Shore Allowance List (COSAL) (shore activities), and the Afloat Replacement Parts Allowance List (ARPAL) (shipboard)
3. In the Consolidated Shipboard Allowance List (COSAL) (shipboard), and the Electronic Repair Parts Allowance List (ERPAL) (shore activities)
4. In the Condensed Shipboard Allowance List (COSAL) (shipboard), and the Electromagnetic Replacement Parts Allowance List (ERPAL) (shore activities)

6-31. The allowance lists are adjusted according to usage rates. How are usage rates determined?

1. By the reporting of failures as prescribed by the 3-M system
2. By applying the percentages shown on a standard probability chart to the record of equipments held
3. By the use of a formula devised by a special study group on logistics
4. By the study of quarterly reports of usage received from all applicable activities

---

Learning Objective: Explain the management of the Naval Warfare Publications Library (NWPL).

6-32. What are the titles of (a) the officer or senior petty officer responsible for the management of the NWPL, and (b) his assistant, who files, makes publication changes, etc?

1. (a) The Naval Warfare Publications Officer (NWPO),
   (b) the NWPL Assistant
2. (a) The Naval Warfare Publications Officer (NWPO),
   (b) the NWPL Clerk
3. (a) The Naval Warfare Publications Custodian (NWPC),
   (b) the NWPL Clerk
4. (a) The Naval Warfare Publications Custodian (NWPC),
   (b) the Naval Warfare Publications Librarian

6-33. What are some of the files used in the maintenance of the NWPL?

1. Signature file (cards containing specimen signatures of all users of the NWPL), custody file (catalog card for each applicable publication on allowance or on board)
2. Administrative file (catalog card for each applicable publication on allowance or on board), transaction file (record of dates and times of all publication check-out/check-in transactions)
3. Signature file (cards containing specimen signatures of all users of the NWPL), administrative file (copies of correspondence pertaining to naval warfare publications)
4. Custody file (catalog card for each applicable publication on allowance or on board), administrative file (copies of correspondence pertaining to naval warfare publications)

6-34. What colors are assigned to the binders for NATO and U.S. tactical warfare publications?

1. Secret - red, Confidential - yellow, Unclassified - blue, with no exceptions
2. Secret - red, Confidential - yellow, Unclassified - blue, except that all of the FXP series, regardless of classification, are red with wide yellow stripes
3. Secret - red, Confidential - yellow, Unclassified - blue, with the following exceptions: NATO classified (any degree) - red, NATO unclassified - white
4. Secret - red, Confidential - yellow, Unclassified - blue, except that all NATO publications, regardless of classification, are white

6-35. It is important to follow proper procedures when changes to NWPL publications are made. Select a response in which all the procedures described are correct.

1. Before the change is made, check the effective date to ensure that the change is effective; make changes in red ink
2. To make a lengthy pen-and-ink correction, carefully cut the affected sheet out of the publication, insert it in the typewriter, line out the superseded material, and type the new material on the top and bottom margins; then fasten the sheet back in the publication, using a good gummed tape
3. To make a lengthy pen-and-ink correction, prepare a typed cutout; then, with a sharp knife or scissors, carefully cut all superseded material out and replace it with the typed cutout
4. Attach flaps to the binder side of the page when there is room enough for a cutout; after pen-and-ink corrections are made, make notations in the margins adjacent to the entries, giving the source of the corrections

6-36. What would the designation "6/2" after "NMC" on a correction received by basegram mean?

1. It is the 6th message correction and will be incorporated into the publication by printed change number 2
2. It is the 2nd message correction and will be incorporated into the publication by printed change number 6
3. It was sent in February 1976
4. It was sent on the 2nd of June

6-37. When the relieving watchstander signs the watch-to-watch inventory of NWPL publications, to what is he attesting other than the fact that he is assuming responsibility?

1. That he will inventory the publications carefully, including page check if required, during his watch
2. That the off-going watchstander has personally declared the security of the publications
3. That a sight inventory of NWPL publications was conducted by the two watchstanders, and any required page checks were conducted
4. That he has carefully checked the communications log of the previous watch, and has sighted publications received and custody cards prepared during the preceding watch

6-38. In new or revised publications, (a) is the effective date always the same for U.S. and Allied usage, and (b) where is the effective date located?

1. (a) Yes, (b) in the foreword
2. (a) No, (b) in the foreword
3. (a) Yes, (b) in the U.S. Letter of Promulgation
4. (a) No, (b) for Allied usage, in the foreword; and for U.S. usage, in the U.S. Letter of Promulgation

---

Learning Objective: Describe the method of filing, and the method and time of destruction of some of the basic files.

6-39. (a) What should the communication center file contain, and (b) in what sequence should the contents be filed?

1. (a) A copy or filler of all messages sent or received by the command and processed by the communications center,
   (b) insofar as possible, by DTG
2. (a) A copy or filler of all messages sent or received by the command and processed by the communications center,
   (b) sequentially by date, but randomly within the same date
3. (a) A copy (no fillers allowed) of all messages sent or received by the command and processed by the communications center,
   (b) insofar as possible, by DTG
4. (a) A copy or filler of all unclassified (but not classified) messages sent or received by the command and processed by the communications center,
   (b) insofar as possible, by DTG

6-40. The cryptocenter file contains a copy of each Top Secret and SPECAT message and other messages designated by the command for special handling or privacy. What other messages, if any, does the file contain?

1. All Confidential and Secret
2. All Secret and only those Confidential that pertain directly to fleet operations
3. All Secret, but no Confidential
4. None

6-41. The general message file contains a copy of all general messages that require retention by the command. How are they filed?

1. By DTG. Each month's messages are filed in a separate folder, and the folders are filed chronologically
2. Subdivided according to title (ALNAV, ALCOM, etc.), and files are arranged in serial number order
3. Chronologically by subject
4. In one folder in strict chronological order

6-42. The broadcast file contains a copy or filler of every message received via the broadcast method. In this file, (a) in what sequence should messages be filed, and (b) what is the period of retention after which messages are destroyed?

1. (a) By broadcast number,
   (b) 30 days
2. (a) By broadcast number,
   (b) 10 days
3. (a) By DTG,
   (b) 10 days
4. (a) By DTG,
   (b) unclassified, 10 days; classified, 90 days

6-43. Normally, (a) what period of time is covered by the supervisor's log, and (b) how often are entries made in it?

1. (a) A radio day, beginning at 0001Z,
   (b) at least once an hour
2. (a) A radio day, beginning at 0800Z,
   (b) at least once an hour
3. (a) A radio day, beginning at 0001, local time,
   (b) every four hours, beginning at 0400, local time
4. (a) One week, beginning at 0001Z each Sunday,
   (b) at the close of each watch

6-44. According to regulations, what is the minimum time for which messages in the following categories must be held: (a) incident to distress or disaster; (b) incident to or involved in a claim or complaint of which the command has been notified; (c) historical or continuing interest?

1. (a) Three years, (b) two years, (c) permanently
2. (a) Four years, (b) two years, (c) permanently
3. (a) Two years, (b) three years, (c) seven years
4. (a) Three years, (b) three years, (c) five years

Learning Objective: State a method or some methods employed to train personnel and enable them to perform their tasks more efficiently.

6-45. Which of the following methods is/are employed to foster and reinforce the knowledge, readiness, and operator proficiency of communications personnel?

1. Cross-training
2. Scheduled checks and inspections
3. Unscheduled checks and inspections
4. All of the above

Learning Objective: Briefly describe espionage organization of today, and identify the publication dealing with the Navy Information Security Program Regulation.

6-46. Which of the following are the usual (a) composition, and (b) work assignments of information-gathering espionage working forces of a country today?

1. (a) A small isolated group of well-trained agents,
   (b) to talk secrets out of high-ranking governmental personnel
2. (a) A small group of highly-trained agents,
   (b) to slip into offices at night and photograph material
3. (a) A fairly large group of people,
   (b) to infiltrate military and political fields only and report those things that sound important to them
4. (a) A large number of people,
   (b) to intermingle with citizens in all fields and gather and report even seemingly unimportant data

6-47. In what publication is the Navy Information Security Program Regulation found?

1. OPNAVINST 4790.4 (series)
2. OPNAVINST 5510.1 (series)
3. OPNAVINST C5510.93 (series)
4. ACP 122

Learning Objective: Identify the administrator of the Navy communications security program.

6-48. To whom has CNO delegated the authority for administering the Navy communications security program?

1. The Commander, Naval Security Group Command
2. The Vice Chief of Naval Operations
3. The Deputy Chief of Naval Operations (Fleet Operations and Readiness)
4. The Deputy Chief of Naval Operations (Plans and Policy)

Learning Objective: Identify the objectives of the recent change in the classification system, the types of material that should be classified, and the names and descriptions of the classification categories.

6-49. A change has recently taken place in the system of classifying and declassifying security information. One objective is to better protect classified material. What are two other objectives?

1. To classify more official information and to declassify less official information
2. To classify less official information and to declassify more official information
3. To classify less official information and to declassify less official information
4. To classify more official information and to declassify more official information

6-50. What should be the security marking on security information, the unauthorized disclosure of which could be expected to cause serious damage to the national security?

1. Crypto
2. Top Secret
3. Secret
4. Confidential

6-51. Information, the revealing of which would be detrimental to national security should bear a security classification. Which, if any, of the following categories of information should also be security-classified?

1. Information regarding the personal life of one or more U.S. citizens only
2. Information that would reflect unfavorably upon officials in public office in the U.S. Government only
3. Information regarding the personal life of one or more U.S. citizens, and information that would reflect unfavorably upon officials in public office in the U.S. Government
4. None of the above

6-52. What should be the security marking on national security information or material, the unauthorized disclosure of which could reasonably be expected to cause damage to the national security?

1. Top Secret
2. Secret
3. Confidential
4. Restricted

6-53 What should be the security marking on national security information or material, the unauthorized disclosure of which could reasonably be expected to cause exceptionally grave damage to the national security?

1. Crypto
2. Top Secret
3. Secret
4. Confidential

Learning Objective: Define various terms depicting special handling.

6-54. What special marking includes all data concerning the design, manufacture, and/or utilization of nuclear weapons and the special nuclear material used in the production of energy?

1. Crypto Data
2. EFTO Data
3. NOFORN Data
4. Restricted Data

6-55. What special marking may be used only in messages and in automatic data processing of intelligence information, and indicates that the information is NOT releasable to foreign governments?

1. EFTO
2. NOFORN
3. LIMDIS
4. FOUO

6-56. What special marking is used to confine the dissemination of copies of such messages to those personnel specifically authorized to have access to that information on a need-to-know basis?

1. EFTO
2. FOUO
3. LIMDIS
4. Restricted Data

6-57. What special marking is affixed to certain unclassified messages to cause them to be given cryptographic protection during transmission?

1. Top Secret
2. Secret
3. EFTO
4. FOUO

6-58. What is the marking assigned to information that is to be processed only by those personnel who have been authorized, in writing, by the commanding officer to view it and which requires special handling beyond that required by the security classification assigned?

1. Top Secret
2. LIMDIS
3. SPECAT
4. Restricted Data

6-59. If a NATO-originated document marked "restricted" is to be in the U.S. in the custody of U.S. personnel for a time, what should be its marking, and like what U.S. classification should it be treated?

1. Restricted, Confidential
2. NATO-Restricted, Confidential
3. Restricted, Secret
4. NATO-Restricted, Secret

Learning Objective: Describe the process of downgrading and declassification of various classifications.

6-60. Normally, when will a document classified Top Secret on 30 Sep 1977 be (a) downgraded to Secret; (b) downgraded to Confidential; and (c) declassified?
1. (a) 30 Sep 1979, (b) 30 Sep 1981, (c) 30 Sep 1987
2. (a) 31 Dec 1979, (b) 31 Dec 1981, (c) 31 Dec 1987
3. (a) 30 Sep 1982, (b) 30 Sep 1987, (c) 30 Sep 1992
4. (a) 31 Dec 1982, (b) 31 Dec 1987, (c) 31 Dec 1992

6-61. Normally, when will a document classified Secret on 30 Sep 1977 be (a) downgraded to Confidential and (b) declassified?
1. (a) 30 Sep 1978, (b) 30 Sep 1982
2. (a) 31 Dec 1978, (b) 31 Dec 1982
3. (a) 30 Sep 1979, (b) 30 Sep 1985
4. (a) 31 Dec 1979, (b) 31 Dec 1985

6-62. Normally, when will a document classified Confidential on 30 Sep 1977 be declassified?
1. 30 Sep 1983
2. 31 Dec 1983
3. 30 Sep 1987
4. 31 Dec 1987

6-63. Exemptions from the General Classification Schedule are made only sparingly. What is the criterion for making such exemptions and when is specific permission from the Director of Naval Intelligence (DNI) required to make them?
1. It must fall into one of the four exemption categories listed in OPNAVINST 5510.1 (series); when broad categories of Top Secret information are placed in an exemption category
2. The judgment of the originator relative to the probable effects of declassification on the security of the country; when more than 1% of a command's Top Secret information is scheduled for exemption
3. It must fall into one of the four exemption categories listed in OPNAVINST 5510.1 (series); when more than 1% of a command's Top Secret information is scheduled for exemption
4. The judgment of the originator relative to the probable effects of declassification on the security of the country; when broad categories of Top Secret information are placed in an exemption category

6-64. Which of the following selections contains only approved markings, one of which normally appears in the last line or paragraph of a classified message?
1. ADS(), DDS(), XDDS()(), XCL()
2. DDS(), GDS(), XXDS()(), SGCL()
3. ADS(), GDS(), XGDS()(), XCL()
4. ADDS(), DDS(), XGDS()(), XXDS()

Learning Objective: Describe the process of marking and reproducing classified material and of classifying titles.

- Judge whether questions 6-65 through 6-68 pertaining to classification marking are True or False.

6-65. The security classification marking of classified material may properly be stamped, printed, or written in large letters, or typed in upper case (all preferably in red).

6-66. If a properly marked classified document is reproduced, the classification marking of the copy must be stamped or marked even when the original marking has reproduced clearly.

6-67. The correct location of paragraph markings, such as (TS), (S), (C), (U), (RD), (FRD), U.K.(C), etc., is immediately preceding and to the left of the part involved.

6-68. Titles and subjects should be classified as they stand alone, regardless of the classification of the related document.

Learning Objective: Distinguish among different categories of security areas.

- Use the following as the alternatives for questions 6-69 through 6-71:

1. Controlled area
2. Exclusion area
3. Isolated area
4. Limited area

6-69. What is the name of an area in which access to classified material can be gained by uncontrolled movement, but such access can NOT be gained if escorts and other controls are properly utilized?

6-70. What is the name of an area in which access to classified material can NOT be gained by uncontrolled movement, such area being used to provide administrative control, safety, or a security buffer function for other areas?

6-71. What is the name of an area in which mere access constitutes, for all practical purposes, access to classified information or material?

Learning Objective: State regulations governing admittance to security areas.

- In addition to your other work, you are assigned the responsibility of admitting without an escort, admitting with an escort, or refusing to admit personnel into the communications area. Using the discussion in your textbook as a criterion, decide which of these actions you should take, on the basis of information given, in the cases of the persons described in questions 6-72 through 6-75, and record your choices of the following alternates:

1. Admit without an escort
2. Admit with an escort
3. Do not admit

6-72. A person who has a proper clearance, says he has a "need to know," and is known to you, but is NOT on the access list.

6-73. A visiting dignitary from Washington D.C. who is interested in communication because he was formerly a Radioman.

6-74. A person who has a proper badge, has a "need to know," and is on the access list.

6-75. A person who is NOT on the access list, but has been specifically granted permission by the commanding officer to visit the communications area.

Assignment 7

Communications Security (Continued); Basic Message Format

Textbook Assignment: Pages 201 - 222

Learning Objective: Describe procedures for maintaining strict accountability of classified material.

7-1. Within each command, strict accountability for classified material must be maintained. What are the titles of the two persons normally designated to maintain accountability? (Sometimes the tasks of both are done by the same person.)

1. Classified Material Manager, Top Secret and Secret Control Officer
2. Classified Material Manager, Classified Material Control Officer
3. Command Security Manager, Top Secret Control Officer
4. Command Security Manager, Classified Material Control Officer

7-2. What markings or method of accountability must be utilized with Top Secret (a) document covers or equipment, (b) messages NOT containing a list of effective pages, and (c) document pages?

1. (a) Copy No._____ of _____ copies;
   (b) Page _____ of _____ pages;
   (c) list of effective pages and page-check page
2. (a) Copy No._____ of _____ copies;
   (b) Page _____ of _____ pages;
   (c) Page _____ of _____ pages
3. (a) Name of command having custody;
   (b) Top Secret, page _____;
   (c) list of effective pages and page-check page
4. (a) Name of person accepting custody;
   (b) Top Secret message: _____ pages;
   (c) Top Secret document: _____ pages

7-3. Which of the following statements regarding the reproduction and accountability of Top Secret documents is correct?

1. Under no circumstances may they be reproduced
2. With the permission of the originator or higher authority one copy (but not more than one) may be reproduced. It must be numbered and recorded with the TSCO
3. They may be reproduced, with the permission of the originator or higher authority. Copies must be numbered serially and recorded with the TSCO
4. They may be reproduced with, and only with, the permission of the commanding officer of the command wishing to reproduce them. Copies must be numbered serially and recorded with the TSCO

Learning Objective: Describe acceptable practices pertaining to safeguarding classified materials.

● Information for question 7-4: You have taken a classified document from storage to work on it at your desk, and now must go a few steps to a coworker's desk to discuss a problem with him.

7-4. What must you do to provide minimum authorized protection for the document while you are thus engaged?

1. Keep it under surveillance
2. Turn it face down or cover it
3. Both 1 and 2 above
4. Replace it in storage

Information for questions 7-5 and 7-6: You are given an assignment to derive some figures, use the figures to complete a worksheet, and then type a duplication of the worksheet as a smooth report (original and one copy), classified Confidential.

7-5. If your typewriter uses a carbon ribbon, which, if any, of the following items besides the carbon and the original and copy of the smooth report must be safeguarded in the manner required for Confidential material?
1. The worksheet and typewriter ribbon
2. The typewriter ribbon only
3. The worksheet only
4. None of the above

7-6. Your typewriter uses a fabric ribbon and this is the fourth time it is being recycled through the machine. Which, if any, of the following items besides the carbon and the original and copy of the smooth report must be safeguarded in the manner required for Confidential material?
1. The worksheet and typewriter ribbon
2. The typewriter ribbon only
3. The worksheet only
4. None of the above

7-7. Which of the following conditions for protecting classified material after working hours is NOT in accordance with security instructions?
1. Classified documents are in locked authorized safes
2. Shorthand notes were not burned, but are in locked authorized safes
3. The contents of wastebaskets containing classified material were not burned, but are in locked authorized safes
4. Burn bags, ready for burning the next day, are securely stapled and neatly lined up along the bulkhead

7-8. Dials on combination locks securing classified material safes must be rotated at least how many times in the same direction to conform to security regulations?
1. Five
2. Two
3. Three
4. Four

7-9. While on duty, an RM2 finds a classified safe open. Which of the following actions should he take?
1. He should lock the safe and inform the senior duty officer only
2. He should inform the senior duty officer and stand guard until he arrives
3. He should recall the responsible person and stand guard until he arrives
4. He should lock the safe, inform the responsible person, and report the incident to the senior duty officer

---

Learning Objective: Describe procedures for the disposal of classified material.

7-10. At the burn site, the burn supervisor must check each bag off the log as it is burned. What else should he and his crew do?
1. They should watch to see that the material is completely burned, and break and scatter the ashes
2. They should stir the fire, be sure that it is burning well, and leave when the last bag goes on the fire
3. They should empty the contents from each bag into the fire, fold the bags for return, watch to see that the material is completely burned
4. They should watch to see that material is completely burned, keep the ashes in a neat pile, and pour water on the ashes before leaving

7-11. Relative to destroying classified material aboard ships at sea by using shredders, what do regulations specify regarding (a) shred width and (b) intermixing of crypto with other material before shredding?
1. (a) Maximum shred width allowed is 1/32 inch, (b) under normal conditions, crypto material must not be intermixed with other material before shredding
2. (a) Maximum shred width allowed is 1/32 inch, (b) crypto material must be intermixed with at least an equal amount of other material before shredding
3. (a) Maximum shred width allowed is 1/16 inch, (b) under normal conditions, crypto material must not be intermixed with other material before shredding
4. (a) Maximum shred width allowed is 1/16 inch, (b) crypto material must be intermixed with at least an equal amount of other material before shredding

7-12. How many witnessing officials to destruction of classified material are required?
1. Five
2. Two
3. Three
4. Four

7-13. To satisfy the requirements of directives, witnessing officials must have a security clearance of at least what level?
1. Confidential
2. Secret
3. Top Secret
4. The level of the material being destroyed

7-14. For a minimum of how long must records of destruction of classified material be maintained?
1. 6 mo
2. 1 yr
3. 18 mo
4. 2 yr

7-15. According to the Emergency Plan of material destruction, what material is of first priority to be destroyed?
1. Top Secret special access material and other Top Secret material
2. Classified components of equipment and Top Secret special access material
3. Communication Security (COMSEC) material and classified components of equipment
4. Communication Security (COMSEC) material and Top Secret special access material

7-16. According to the Emergency Plan, what material should be destroyed immediately before Secret special access material?
1. Other Secret material
2. Top Secret material (not special access)
3. Top Secret special access material
4. Classified components of equipment

7-17. What should normally be done with superseded classified material?
1. It should be retained indefinitely, as it is difficult to get another copy
2. It should be retained for two years, then destroyed
3. It should be retained for one year, then destroyed
4. It should be destroyed immediately

Learning Objective: Define terms related to COMSEC and other classified material.

7-18. Communications security (COMSEC) is the overall effort to protect the integrity and validity of our communications community. Besides cryptosecurity and physical security, what does COMSEC include?
1. Transmission security and organizational security
2. Emission security and reception security
3. Transmission security and emission security
4. Emission security and organizational security

7-19. What is the expression normally used to state that it has been discovered or is suspected that an unauthorized person has gained access to classified material?
1. The material has been compromised
2. The material has been violated
3. The material has been defiled
4. The material has been wasted

7-20. What is an accountability legend?
1. A brief written account of the date and circumstances surrounding the acquisition of each classified item held
2. A brief written description of the subject, number of pages, etc. of each classified item held
3. A disclosure record, or list of signatures of all viewers of each classified item held
4. A number assigned to COMSEC material to govern the handling procedure

- Use the following as the alternatives for questions 7-21 through 7-23:

  1. CMS Holder
  2. CMS Satellite Holder
  3. CMS Local Holder
  4. CMS Responsible User

7-21. What is the term used to specify a ship whose COMSEC material needs are met by drawing such materials from the squadron commander?

7-22. What is the term used to specify a command which has an account number and draws its COMSEC materials directly from national or Navy distribution sources?

7-23. What is the term used to specify an officer who draws CMS material from the CMS custodian of his command by signing and assuming responsibility for it?

Learning Objective: Define and indicate the scope and coverage of several terms connected with cryptosystems, and state qualifications required by a cryptographic operator.

7-24. Which of the following describes crypto-related information?
1. Always classified
2. Significantly descriptive of cryptomaterial
3. Normally associated with, but not significantly descriptive of cryptomaterial
4. Normally marked "CRYPTO"

7-25. It is vitally important that all items in a cryptosystem be given the strictest security. What is the term for a situation in which this security is NOT strictly maintained?
1. Crypto-exposure
2. Crypto-instability
3. Crypto-deficiency
4. Crypto-insecurity

7-26. Cryptographic operators must have proper security clearance, authorization from the commanding officer to perform crypto duties in his command, and familiarity with local crypto procedures. What other minimal qualifications, if any, are there?
1. Normal vision and manual dexterity
2. Achievement of E-4 or higher
3. Attainment of age 21 or higher
4. None

Learning Objective: State the priority order of the emergency destruction of keying materials.

7-27. In case of emergency destruction, keying material, as the most sensitive material, is destroyed first. What are the three types of keying material in the priority order of their destruction (within each security classification)?
1. Superseded, reserve, effective
2. Effective, superseded, reserve
3. Reserve, effective, superseded
4. Superseded, effective, reserve

Learning Objective: Identify the words for which EMCON stands, and define the terms meaconing, interference, jamming, and intrusion.

7-28. For what words does "EMCON" stand?
1. Emission control
2. Emission continuation
3. Emergency control
4. Emergency concealment

7-29. What is "meaconing"?
1. Intermittent power on/power off emission, five seconds on, five seconds off
2. Emission on a "sliding" frequency, a procedure of moving up in frequency a prescribed degree each three minutes to a prearranged maximum, then down in the same manner
3. Interception and rebroadcast of beacon signals on the same frequency
4. A category of communications interference that includes jamming and intrusion, among others

7-30. What is "interference," as used in the context of U.S. naval communications?

1. The deliberate use of electromagnetic signals with the object of impairing communication circuits
2. Any attempt by the enemy to enter the U.S. or Allied communications system and simulate our traffic with intent to confuse or deceive
3. A break in the electric line or any other equipment failure that impedes the process of communications
4. A nondeliberate electrical disturbance which prevents the effective use of a frequency

7-31. What is "jamming"?

1. Distortion caused by transmitting with too much power for the existing circuits
2. The deliberate use of electromagnetic signals with the object of impairing communication circuits
3. Emission on a "sliding" frequency, a procedure of moving up in frequency a prescribed degree each three minutes to a prearranged maximum, then down in the same manner
4. Interception and rebroadcast of beacon signals on the same frequency to confuse enemy navigation

7-32. What is "intrusion"?

1. The deliberate use of electromagnetic signals (such as by random noise) with the object of impairing communication circuits
2. The inadvertent selection and use of a frequency by an operating unit when another unit in the area is already using that frequency for official traffic
3. The unintentional splatter of an over-modulated signal into an adjacent in-use frequency
4. An attempt by the enemy to enter the U.S. or Allied communication systems and simulate our traffic with intent to confuse and deceive

---

Learning Objective: State who prescribes or approves the cryptographic systems and techniques used by military personnel, indicate the minimum frequency of COMSEC inspections, and identify the actual inspectors.

7-33. How often must a command have a COMSEC inspection, and what delegation actually visits?

1. Once a year; a delegation from the staff of the Naval Security Group Command
2. Once every six months; a delegation from the staff of the Naval Security Group Command
3. Once a year; a delegation from a local Naval Security Group
4. Once every six months; a delegation from a local Naval Security Group

7-34. What organization, acting in behalf of the Secretary of Defense, prescribes or approves all cryptographic systems and techniques used by all branches of the military and approves or produces all cryptomaterial used by the departments and agencies of the U.S.?

1. The Joint Army-Navy Information Center (JANIC)
2. The National Security Agency (NSA)
3. The Naval Security Group Command (NAVSECGRU)
4. The Naval Intelligence Command (NIC)

Learning Objective: Describe the contents of a communication center visitor's log.

7-35. For the communication center visitor's log, what column headings besides date, visitor's signature, rank or grade, organization represented, and time in and time out are recommended by KAG 1?

1. Social Security number, signature of authority authorizing visit
2. Date of birth, local address and telephone number, name of authority authorizing visit
3. Purpose of visit, signature of authority authorizing visit
4. Place and date of birth, signature of authority authorizing visit

---

Learning Objective: Identify the location of specific information pertaining to communications operations.

A. ACP 122
B. CMS 4
C. KAG 1
D. NTP 4
E. NWP 4
F. NWP 33
G. OPNAVINST 5510.1 (series)

List 7A.

- Refer to list 7A in answering questions 7-36 through 7-45.

7-36. What publication contains equivalent U.S. security markings for material marked with foreign security classifications?
1. B
2. C
3. E
4. G

7-37. What publication outlines the duties of the Command Security Manager?
1. B
2. C
3. E
4. G

7-38. What publications contain complete terms, areas, items, and sub-categories relative to COMSEC material?
1. A and D
2. B, C, and E
3. D and F
4. F and G

7-39. In what publication(s) is/are complete information on the security marking and re-marking of classified messages located?
1. A only
2. A and B
3. E and F
4. G

7-40. What publications contain the priorities and methods of destruction of COMSEC material (in addition to those requirements discussed in OPNAV 5510.1 (series)?
1. B and C
2. B and E
3. C and D
4. D and F

7-41. What publications contain effective methods of dealing with the occurrence of any component of "MIJI"?
1. A, B, and D
2. B and C
3. D and F
4. E and F

7-42. What publication contains procedures governing the COMSEC Material Control System?
1. A
2. B
3. D
4. F

7-43. In what publication(s) is/are the responsibilities of the NSA listed?
1. A and B
2. B and C
3. E
4. F

7-44. What publication lists situations in which authentication is either mandatory or merely advisable?
1. A
2. C
3. D
4. F

7-45. What publication contains complete information on paragraph, sub-paragraph, and document marking?
1. A
2. C
3. E
4. G

Learning Objective: Determine the specific format lines of a basic Navy message to which various portions of the contents are assigned.

7-46. Which format lines in a naval message are used for the station(s) called and the station(s) calling?
1. Lines 1 and 2
2. Lines 2 and 3
3. Lines 1 and 3
4. Lines 3 and 4

7-47. In which format line is the accounting symbol or group count?
1. Line 3
2. Line 5
3. Line 9
4. Line 10

7-48. In which format lines are the FM and TO addressees given?
1. Lines 4 and 5
2. Lines 5 and 6
3. Lines 6 and 7
4. Lines 7 and 8

7-49. Identify the format line containing the precedence indicator, DTG, and specific handling or delivery instructions.
1. Line 1
2. Line 2
3. Line 5
4. Line 4

7-50. With which format lines do the heading, text, and ending, respectively, of a basic naval message begin?
1. 1, 8, 13
2. 1, 11, 15
3. 1, 12, 14
4. 2, 10, 14

Learning Objective: Identify the four components of the message heading.

7-51. What are the four components that comprise the heading called?
1. Classification, origination, destination, and salutation
2. Beginning procedure, preamble, address, prefix
3. Original call-up, accounting procedures, address, prefix
4. Opening remarks, classification, originator's call, addressee's call

---

Learning Objective: Interpret or properly record date-time groups, abbreviation "GR" with number, and prosign $\overline{\text{BT}}$.

7-52. Which of the following is a correct example of a date-time group as used in the heading of a message?
1. 0815Z 15 Jan 78
2. 15 Jan 78 0815Z
3. 150815S Jan 78
4. 150815Z Jan 78

7-53. What would "GR20" mean in a message?
1. The text contains 20 words
2. The entire message contains 20 words
3. The message is assigned "general routine 20" priority
4. This is the 20th message of the day from the originator

7-54. What does the prosign $\overline{\text{BT}}$ mean?
1. Break
2. The Navy has financial responsibility
3. Bravo transmission
4. Blind transmission

Learning Objective: Describe standard format and composition of a basic naval message.

7-55. If a message text has 15 typed lines, how many format lines does the text comprise?
1. 1
2. 5
3. 3
4. 15

7-56. Special handling instructions such as SPECAT or PERSONAL FOR are placed on the same line as which of the following?
1. The TO addressee(s)
2. The security classification category
3. The precedence and DTG
4. The accounting information

7-57. What is the composition of the SSIC, and what punctuation, if any, precedes and follows it?
1. A letter (variable) followed by five numbers; two slashes precede and two slashes follow
2. A letter (variable) followed by six numbers; a semicolon precedes and no punctuation follows
3. The letter "N" followed by five numbers; a semicolon precedes and a semicolon follows
4. The letter "N" followed by five numbers; two slashes precede and two slashes follow

7-58. What does a passing instruction include?
1. The addressed command's short title then the office code or individual's name
2. The addressed command's long title, then the office code or individual's name
3. The addressed command's short title, then the office code only
4. The addressed command's long title, then the office code, then the individual's name

7-59. Which of the following statements is correct concerning the format of references in a message?
1. They are numbered consecutively and listed one beneath another
2. They are lettered consecutively and listed one beneath another
3. They are numbered consecutively and listed one following the other, separated by semicolons
4. They are lettered consecutively and listed one following the other, separated by semicolons

7-60. Which of the following statements is correct concerning the numbering and lettering, if any, of textual paragraphs and subparagraphs?
1. Textual paragraphs are numbered and subparagraphs are lettered. Single paragraphs must be numbered "1."
2. Textual paragraphs are numbered, but subparagraphs are neither numbered nor lettered. Single paragraphs are numbered "1."
3. Textual paragraphs are numbered and subparagraphs are lettered. Single paragraphs need not be numbered.
4. No textual paragraphs nor subparagraphs are numbered or lettered

7-61. If a paragraph of a message is Secret and also Restricted Data, what marking, if any, will be recorded immediately preceding the words of the paragraph?
1. SECRET-RESTRICTED DATA
2. SECRET-RD
3. SRD
4. None

7-62. In the time group "1030R," what does the "R" mean?
1. Restricted
2. Release time of message
3. Receipt time of message
4. The time zone designation

7-63. What are the ending sign prowords and prosigns used for voice and CW or TTY transmission, respectively?
1. OVER or OUT; K or $\overline{\text{AR}}$
2. ROGER; K or $\overline{\text{AR}}$
3. OVER or OUT; $\overline{\text{BT}}$
4. ROGER; $\overline{\text{BT}}$

Learning Objective: Determine who is responsible for the various details involved in the composition, authorization, and transmission of a naval message.

Use the following as the alternatives for questions 7-64 through 7-66:

1. The drafter

2. The releaser

3. The originator

7-64. Who authorizes the message for transmission after validating its contents and ensuring compliance with applicable directives?

7-65. In whose name is the message sent?

7-66. Who is responsible for actually composing the message, addressing, selecting the proper classification, issuing declassification and downgrading instructions, formatting, and selecting the precedence?

Learning Objective: Explain the meanings of the precedence indicators.

7-67. What is the precedence prosign which identifies the Emergency Command Precedence (ECP) in the AUTODIN system?
1. V
2. W
3. X
4. Y

- Use the following as the alternatives for questions 7-68 through 7-71:

  1. Flash
  2. Immediate
  3. Priority
  4. Routine

7-68. What should the precedence indicator be for messages relating to situations which gravely affect the national forces or populace and which require immediate delivery to addressees?

7-69. What should the precedence indicator be for initial enemy contact reports or operational combat messages of extreme urgency?

7-70. What should the precedence indicator be for all types of traffic which should be transmitted electrically, but do NOT warrant a higher precedence than the type assigned?

7-71. What should the precedence indicator be for messages which furnish essential information for the conduct of operations in progress? (This is the highest precedence usually authorized for administrative messages.)

Assignment 8

Basic Message Format (Continued)

Textbook Assignment: Pages 223 - 245

Learning Objective: Distinguish among classes of messages.

- Messages are placed in classes A, B, C, D, or E for administrative and accounting purposes. In questions 8-1 through 8-6, select the class(es) into which the messages used as the question may be put.

8-1. Government messages.
1. A and B only
2. C, D, and E
3. A, B, and C only
4. A, B, C, and D

8-2. Broadcast traffic available to ships of all nationalities, such as hydrographic data, weather, etc.
1. A
2. B
3. C
4. D

8-3. Personal messages to or from naval personnel, handled primarily free of charge over naval circuits.
1. A
2. B
3. C
4. E

8-4. Messages originated by and destined for DOD activities (includes the Coast Guard when it is operating as part of the Navy). Most Navy messages are in this class.
1. A
2. B
3. D
4. E

8-5. Messages originated by and destined for U.S. Government agencies other than DOD.
1. A
2. B
3. D
4. E

8-6. Private messages for which the Navy collects tolls. Includes radiotelegrams and press messages sent by correspondents aboard ship.
1. A
2. B
3. C
4. D

Learning Objective: Distinguish among the various types of messages according to the method of addressing.

- Messages may be divided into types, according to the way they are addressed. Use the following as the alternatives for questions 8-7 through 8-10:

1. Book

2. General Message

3. Multiple-Address

4. Single-Address

8-7. What kind of message is destined for two or more addressees, none of whom is informed of any other addressee?

8-8. What kind of message is destined for two or more addressees, each of whom is informed of all other addressees?

8-9. What kind of message is destined to meet recurrent requirements for a wide, predetermined, standard distribution?

8-10. What kind of message is normally titled (e.g., ALCOM, NAVOP, JAFPUB, etc.) with the title indicating distribution?

Learning Objective: Demonstrate an awareness of the characteristics of the different formats (plaindress, etc.) of messages.

● Use the following as the alternatives for questions 8-11 through 8-13:

1. Abbreviated plaindress
2. Codress
3. Plaindress
4. None of the above

8-11. Which, if any, of the preceding is a message format which is used very extensively in voice communications, and may be used in other formats, and in which the initial call serves as the address, and the precedence, date, date-time group, and group count may be omitted?

8-12. Which, if any, of the message formats listed is always encrypted, always contains a group count, and includes the entire address component within the encrypted text?

8-13. Which, if any, of the message formats listed contains all of the components of the basic message except that the group count at times may be omitted, and contains the originator and addressee designations externally in the address component?

Learning Objective: Describe radio call signs and voice calls used under given circumstances.

8-14. Which of the following is an example of an international call sign for a naval shore station, a naval vessel, and a naval aircraft, respectively?
1. NCAW, NAU, N4398
2. NAU, N4398, NCAW
3. N4398, NCAW, NAU
4. NAU, NCAW, N4398

8-15. In voice communications, how should a ship identify on ship-shore administrative circuits, excluding local harbor circuits?
1. By phonetically spelled international call signs
2. By voice call signs as listed in JANAP 119
3. By voice call signs as listed in ACP 119
4. By the name of the ship

8-16. What is the name of a call sign which represents all of a group of stations in direct contact with each other on a common channel?
1. Group call sign
2. Net call sign
3. Detachment call sign
4. Cluster call sign

Learning Objective: Demonstrate a basic familiarity with address groups and routing indicators.

8-17. Address groups are four-letter groups assigned to represent certain commands, activities, or units. How can they be distinguished from Navy four-letter international radio call signs?
1. Address groups are transmitted with a slight pause between the second and third letters
2. Address groups are transmitted with a slight pause between the third and fourth letters
3. Address groups are always transmitted twice
4. Address groups, in contrast to Navy call signs, do not begin with "N"

8-18. Which type of address group must always have more information added to it to serve as a complete station and address designator?
1. Individual activity address groups
2. Collective address groups
3. Conjunctive address groups
4. Address indicating groups

8-19. Geographic address groups are always preceded by
1. individual activity address groups
2. collective address groups
3. conjunctive address groups
4. address indicating groups

487

8-20. Which of the following is a purpose of address indicating groups?
1. To reduce the number of address groups required in the heading of a message
2. To convey special instructions in the heading of a message
3. To provide an alternate address group in the event that the primary address group is compromised
4. To locate the originator of a message geographically

8-21. What is the first letter of routing indicators used with communications relay networks, and how many letters do they have?
1. C; three to six
2. C; four
3. R; three
4. R; four to seven

Learning Objective: Describe procedures to be used by a flag rank commander temporarily detached from headquarters location to send a message to his staff; describe procedures for message readdressal.

8-22. Which of the following is a correct example of the "From" and "To" of a message sent by a flag rank commander to his staff when he is temporarily detached from his headquarters location?
1. FM COMSUBLANT NORFOLK VA (TDY AWAY)
   TO COMSUBLANT NORFOLK VA
2. FM COMSUBLANT NORFOLK VA
   TO SUBLANT NORFOLK VA
3. FM COMSUBLANT NORFOLK VA
   TO ADMIN COMSUBLANT NORFOLK VA
4. FM ADMIN COMSUBLANT NORFOLK VA
   TO COMSUBLANT NORFOLK VA

8-23. What is the correct procedure for your command to use to readdress a message?
1. Delete format lines 1 through 4, precede the remainder with a complete heading from your command
2. Replace the heading of the message with one from your command
3. Replace format lines 1 through 5 with format lines 1 through 5 from your command
4. Leave the message intact, immediately precede it with a supplementary heading from your command

---

Learning Objective: State the normal cancellation date of a message.

8-24. When will a message directive be automatically cancelled if it is NOT cancelled prior to this time by other means?
1. Sixty days after the release date
2. Ninety days after the release date
3. Four months after the release date
4. Six months after the release date

Learning Objective: Identify the meanings of various prosigns and Q and Z signals, and state how to identify general messages.

To answer questions 8-25 through 8-28, select from column B the precedence prosign which corresponds to the precedence as given in word form in column A.

	A. Precedences	B. Precedence Prosigns
8-25.	Flash	1. O
8-26.	Immediate	2. P
8-27.	Priority	3. R
8-28.	Routine	4. Z

8-29. What does the prosign AA mean when it is used to identify a portion of a transmission?
1. All after
2. All above
3. Action addressee
4. Alternate addressee

8-30. What does the prosign K mean?
1. If the message relates to another command, you are requested to readdress
2. This is the end of my transmission to you, and a response is invited
3. Negative report is not required
4. Stand by -- a weather report of significance will follow

8-31. What does the pause prosign AS AR mean?
1. I must pause for a few seconds
2. I must shut down operations for one hour
3. I must pause _____ minutes (Always followed by a number)
4. I must pause longer than a few seconds; will call you back

8-32. What is the meaning of the prosign F used in transmission instructions?
1. Do not answer
2. This is the final transmission at this time
3. Forward to applicable command after readdressing
4. Repeat this entire transmission back to me exactly as received

8-33. What does the prosign $\overline{IX}$ plus a 5-second dash mean, in relation to the executive method?
1. Execution must be complete within one minute. Report required after execution
2. Execute -- carry out the purpose of the message
3. You will receive execute orders within five minutes
4. Stand by for execute order

To answer questions 8-34 through 8-37, select from column B the prosigns which carry the same meaning as the statements given in column A.

	A. Prosign Meanings	B. Prosigns
8-34.	More to follow	1. B
8-35.	Emergency silence	2. EEEEEEEE $\overline{AR}$
8-36.	This transmission is in error. Disregard it	3. $\overline{HM}$ $\overline{HM}$ $\overline{HM}$
		4. $\overline{IMI}$
8-37.	Repeat	

8-38. What are three-letter groups beginning with Q or Z used to convey much longer expressions properly called?
1. Code signals
2. Operating signals
3. Prosigns
4. Prowords

8-39. How can general messages be identified as such?
1. By the "GEN" in the heading
2. By the repetitive short title (e.g., ALNAV, JAFPUB)
3. By the double spacing between format lines five and six
4. By the prosign G in the transmission instructions line

Learning Objective: Describe various types of messages and associated procedures.

8-40. How are general messages which are NOT of sufficient operational urgency to warrant immediate delivery to forces afloat handled?
1. By the use of minimize conditions
2. By basegrams
3. By nightletters
4. By "Q" messages

8-41. What must a general message file contain?
1. Every general message received during the current two-year period
2. Only those general messages received for action during the current two-year period
3. Every general message received during the calendar year
4. Only those general messages received for action during the calendar year

8-42. Which of the following statements regarding cancellation of general messages is correct?
1. The first general message of a calendar year lists those messages of the previous year (by number) that are cancelled
2. An individual general message may include its own cancellation date in parentheses after the signature
3. A message is automatically cancelled upon receipt of a subsequent message of the same series
4. General messages which do not have a yearly cancellation message and are not assigned particular cancellation dates are automatically cancelled after 90 days

8-43. If an originator designates a message as a basegram, where should the word "BASEGRAM" appear in the message?
1. In the message instructions
2. As the first word of the text immediately following the classification
3. As the last word of the text
4. Immediately following the date-time group

8-44. Which of the following actions must be taken prior to the transmittal of American Red Cross emergency or administrative traffic over naval communications facilities?
1. A toll must be collected from the American Red Cross
2. Verification must be made that the precedence assigned is not higher that ROUTINE
3. A genuine effort must have been made by the American Red Cross to transmit the message by commercial means
4. The approval of the commanding officer must be obtained

8-45. During minimize conditions, what is the maximum allowable number of words for (a) FLASH and (b) IMMEDIATE traffic?
1. (a) 100, (b) 150
2. (a) 100, (b) 200
3. (a) 125, (b) 200
4. (a) 150, (b) 225

8-46. Normally, by what means should delivery of traffic on hand be made when minimize conditions are in effect?
1. By airmail letters and speedletters, observing security precautions
2. By registered mail, observing security precautions
3. By regular circuits between 0001 and 0400 local time
4. By regular circuits after minimize conditions are lifted

8-47. What are proforma messages?
1. Messages, the subject matter and content sequence of which are preset and can not be changed by the originator
2. Messages destined for two or more addressees, each of whom must be informed of all the others
3. Messages destined for two or more addressees, none of whom is informed of the others
4. Messages in which the entire address component is included within the encrypted text

8-48. What is a "Q" message?
1. A short concise message between communications personnel dealing with such things as misrouted or missent messages, etc
2. A message sent to determine the reason for nondelivery or delay in delivery of a message
3. A classified portion of Allied navigational warning systems
4. A message of FLASH precedence which has a pre-set format and contains key instructions from high-level authority

8-49. Which of the following statements describes the procedure specified in your rate training manual respecting the timeliness or absence of response to a service message?
1. Action should be taken promptly. Any significant delay in accomplishing the action should be reported to the originator of the SVC
2. Action should be taken on all service messages before the processing of routine traffic, but after the processing of traffic of higher precedence
3. Action should be accomplished on a "time available" basis after all traffic is cleared
4. A service message is always in the form of a report of action taken, and does not require that further action be taken

8-50. Which of the following is a correct example of the beginning of the text of a service message?
1. UNCLAS SVC
2. 180725Z UNCLAS SVC
3. SVC YOUR DTG 121531Z
4. SVC 180725Z UNCLAS

8-51. Upon receipt of a tracer message, an activity should examine its records for the time of transmission of the message, compile this information with received data, and transmit it, with the tracer action to the
1. originator of the tracer message only
2. preceding station only
3. originator of the tracer message, and the preceding station only
4. originator of the tracer message, the preceding station, and the following station

8-52. How could a ship establish a circuit with another station?
1. By sending a circuit establishment request message to the applicable NAVCOMMTECHGRU
2. By sending a termination request message to the NAVCAMS in whose area the ship is operating
3. By sending a request for an additional circuit by naval message to the Commander, Naval Telecommunications Headquarters
4. By sending a request by naval message to the cognizant fleet commander in chief, requesting additional communications linkage

8-53. Which of the following statements is a correct description of JCS Emergency Action Messages?
1. They have a predetermined format and normally carry IMMEDIATE or PRIORITY precedence, depending upon the degree of time-sensitivity
2. The format is not predetermined, but must be brief and concise; normally of IMMEDIATE precedence, but may be FLASH; are highly (sometimes extremely) time-sensitive
3. The format is not predetermined, but has become fairly standardized through usage; normally carry FLASH precedence; and are extremely time-sensitive
4. They have a predetermined format, normally carry FLASH precedence, and are extremely time-sensitive

8-54. The text of a certain message begins "CHECK ONE EIGHT." What precedence has it?
1. ROUTINE
2. PRIORITY
3. IMMEDIATE
4. FLASH

8-55. The OCR rapidly and accurately transcribes a typewritten outgoing message into a language compatible with computer processing. What does "OCR" stand for?
1. Outgoing Computer Run
2. Optical Character Reader
3. Optical-to-Computer Replacement
4. Outgoing Continuous Reader

Learning Objective: Use the Joint Messageform, DD-173. (This objective is continued in Assignment 9.)

8-56. Joint Messageform, DD-173, is available in two colors. (a) What are the colors, and (b) what determines which color a particular activity should use?
1. (a) Orange and light green, (b) the geographical location
2. (a) Orange and light green, (b) the type of equipment used by the serving telecommunications center
3. (a) Red and light blue, (b) the geographical location
4. (a) Red and light blue, (b) the type of equipment used by the serving telecommunications center

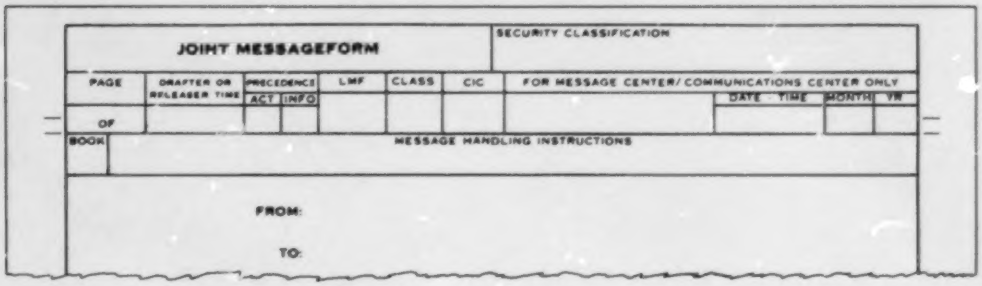
---

To answer questions 8-57 through 8-59, select from column B the spacing format appropriate to the part of the DD-173 shown in column A.

	A. Parts of DD-173	B. Spacing Formats
8-57.	Header lines and address component	1. Single-spaced
		2. Double-spaced
8-58.	Text	
		3. Triple-spaced
8-59.	Distribution block	

8-60. The paper guide should be set at 0 when you are preparing the DD-173. What are the correct settings for the left and right margins, respectively?
1. 4, 73
2. 5, 74
3. 6, 75
4. 8, 77

8-61. Which of the following methods of correction is acceptable for correcting a typing error in the headerlines?
1. Erasing
2. Striking over the error with a slash and typing the correct character in the next space
3. Striking over the error with a "blob" and typing the correct character in the next space
4. Attaching self-adhesive correction tape and retyping



JOINT MESSAGEFORM

SECURITY CLASSIFICATION

PAGE

OF

DRAFTER OR RELEASER TIME

PRECEDENCE

ACT

INFO

LMF

CLASS

CIC

FOR MESSAGE CENTER/COMMUNICATIONS CENTER ONLY

DATE - TIME

MONTH

YR

BOOK

MESSAGE HANDLING INSTRUCTIONS

FROM:

TO:

Figure 8A. - Top of a Joint Messageform, DD-173.

- ● In answering question 8-62, refer to figure 8A.

8-62. What, if anything, should be typed between the horizontal lines indicated by arrows?
1. The classification indication
2. The precedence indication
3. Any character
4. Nothing

- ● Information for question 8-63: You are typing on a DD-173 the fourth page of a message which you thought would be completed on the fourth page. You now realize that a fifth page will be required. You have numbered the first four pages "01 of 04" through "04 of 04," respectively.

8-63. How should the page numbers of the five pages read when the message is complete?
1. "01 of 04" through "05 of 04"
2. "01 of 05" through "05 of 05"
3. "01 of 04" through "03 of 04"; "04 of 05"; and "05 of 05"
4. "01 of 04" through "04 of 04"; and "05 of 05"

8-64. What does "1221537" in the time block mean?
1. 122nd day, 1537 Greenwich Mean Time
2. 12th month, 2153 Greenwich Mean Time, 7 = page check
3. 12th month, 2153 local time, time zone = +7
4. 1st month, 22nd day, 1537 Greenwich Mean Time

8-65. A message could correctly display which of the following notations in its Action Precedence, Info Precedence, and Classification blocks, respectively?
1. VV; RR; UUUU
2. RR; PP; UUUU
3. RR; RR; OOOO
4. PP; RR; CCCC

8-66. What operating signals are inserted in the Message Handling Instructions block to indicate that a message must be handled as a book message?
1. ZYZ
2. ZYQ
3. ZZQ
4. ZWQ

8-67. Which of the following is correct concerning the address used on a DD-173?
1. It must include the PLA as given in the PLAD, after which amplifying details of address may be added in parentheses
2. It must include the PLA as given in the PLAD, clarified, as desired, by inserting commas and periods (but no other punctuation)
3. It must be exactly as given in the PLAD; no characters may be omitted or added

8-68. Continuation lines may NOT be used with which of the following PLAs?
1. The originator's PLA
2. The action addressee's PLA
3. The info addressee's PLA
4. The exempt addressee's PLA

8-69. What is the meaning of the operating signal "ZEN" appearing before some action or information addressees?
1. Such addressees are to reply within twenty-four hours
2. Such addressees will receive a mailed copy of the message in addition to the electrically-sent one
3. Such addressees are to receive the message by other means
4. Such addressees need not respond if they comply without delay; however, if compliance is impossible or delayed, they must reply within twenty-four hours

8-70. What is the correct form and spacing in the classification line to indicate (a) an unclassified message, and (b) a Confidential message?

1. (a) UNCLAS,
   (b) C O N F I D E N T I A L
2. (a) UNCLAS,
   (b) CONF
3. (a) UNCLASSIFIED,
   (b) CONFIDENTIAL
4. (a) U N C L A S S I F I E D,
   (b) C O N F I D E N T I A L

8-71. How many slant signs (a) precede, and (b) follow the Standard Subject Identification Code (SSIC)?

1. (a) 1, (b) 1
2. (a) 2, (b) 2
3. (a) 2, (b) 4
4. (a) 4, (b) 4

8-72. When passing instructions are used, they should begin at tab stop 6, one double-spaced line below the

1. message instructions
2. precedence and DTG
3. last addressee
4. classification line

8-73. What is the maximum number of spaces that text lines may be indented for graphic clarity?

1. 10
2. 12
3. 18
4. 20

8-74. Which of the following lines displays the correct format of the line one double-space below the last addressee of a readdressed message?

1. RADDR 785431
2. JCS WASHINGTON DC//122037Z MAY 78
3. RADDR//122037Z MAY 78
4. RADDR JCS WASHINGTON DC//122037Z MAY 78

Assignment 9

Basic Message Format (continued); Radiotelephone Procedures

Textbook Assignment: Pages 218 - 265

Learning Objective: (Continued) Use the Joint Messageform, DD-173.

● Questions 9-1 and 9-2 are to be judged True or False.

9-1. When a message is referenced, the originator's complete PLA should be given, followed by the DTG, month, and year.

9-2. The four-character security redundancy code and the precedence of readdressal messages must be the same as the message being readdressed.

Learning Objective: Identify the publications containing specific instructions relative to each of a number of procedures.

A. ACP 100 and/or supplement
B. ACP 113
C. ACP 124
D. ACP 131
E. JANAP 128
F. NTP 3 and/or supplement
G. NTP 4
H. NTP 9
I. NWP 4
J. NWP 7 and/or appendix

List 9A.

● In answering questions 9-3 through 9-8, select from list 9A the publication to which you have been directed by your textbook to find information on the subject used as the question.

9-3. The usage of various accounting symbols for messages.
1. A
2. D
3. G
4. H

9-4. Classification line markings.
1. B
2. C
3. F
4. H

9-5. Authorized punctuation marks and their abbreviated equivalents.
1. A
2. E
3. F
4. J

9-6. Call signs for fixed and land radio stations.
1. A
2. B
3. C
4. D

9-7. International and military call signs for ships.
1. B
2. E
3. G
4. I

9-8. The Plain Language Address Directory (PLAD).
1. A
2. C
3. E
4. F

A. ACP 100 and/or supplement

B. ACP 113

C. ACP 124

D. ACP 131

E. JANAP 128

F. NTP 3 and/or supplement

G. NTP 4

H. NTP 9

I. NWP 4

J. NWP 7 and/or appendix

List 9B.

- In answering questions 9-9 through 9-15, refer to list 9B.

9-9. Authorized operating signals.
1. C
2. D
3. F
4. H

9-10. The types of general messages, from whom they originate, and their distribution.
1. E
2. H
3. I
4. J

9-11. Types of normal, environmental, and supply messages that may be sent over normal channels and circuits during minimize.
1. E
2. G
3. I
4. J

9-12. Instructions for preparing movement reports.
1. B
2. G
3. I
4. J

9-13. Detailed information about tracer procedures.
1. D
2. E
3. I
4. J

9-14. Instructions regarding communications shift messages and their formats.
1. B
2. C
3. D
4. G

9-15. Instructions regarding readdressing a message.
1. F
2. H
3. I
4. J

Learning Objective: Point out a disadvantage of using radiotelephone, and distinguish proper from improper operating procedures.

9-16. There are many advantages to the use of radiotelephone. What is an important disadvantage?
1. Radiotelephone equipment is quite difficult to use
2. Radiotelephone procedures necessitate the use of more expendable supplies than most other methods of communication
3. Radiotelephone communication is slower than communication by most other methods
4. With radiotelephone communications, there is an inherent danger of interception

9-17. Which of the following is a prescribed operating procedure for the maintenance of good circuit discipline and transmission security?
1. Frequent tuning and testing of the equipment (every time anyone can find a free moment to conduct tests) in order to keep the equipment squarely on frequency
2. Use of a directed net only with permission
3. Use of plain language rather than prowords to avoid any misunderstanding
4. Positive identification of your transmission with your name or personal sign

Learning Objective: Define beadwindow and EEFIs.

9-18. What is a beadwindow?
1. A rapid method of sending encrypted messages
2. A method of multiple-addressing radiotelephone messages to ensure wide dissemination
3. A means used by net control, on a directed net, to get rapid confirmation that all stations in the group are receiving satisfactorily
4. A means of immediately notifying circuit operators of an unauthorized disclosure

9-19. What are EEFIs?
1. Essential Elements of Friendly Information
2. Electronic Encryptions of Friendly Information
3. Electronic Emissions of False Information
4. Enemy-Effected Fact Interceptions

9-20. Which of the following is a correct reply to a beadwindow message?
1. "CONTROL, THIS IS (name of station), WILCO, OUT"
2. "CONTROL, THIS IS (name of station), ROGER, OVER"
3. "CONTROL, THIS IS (name of station), ROGER, OUT"
4. "CONTROL, MESSAGE RECEIVED, (name of station), OUT"

Learning Objective: Recognize the contents and importance of an RM's duties.

- Judge whether questions 9-21 and 9-22, regarding responsibilities of an RM, are True or False.

9-21. On relatively large ships, voice circuits are handled from the bridge and CIC. As an operator, you would be responsible for establishing transmitter and receiver services to those locations, which may be located a considerable distance from the communications spaces.

9-22. It is vital for an RM on a ship to know which nets are guarded by his ship, to know their purposes, and to be able to establish communications on a net or circuit.

Learning Objective: Identify the three parts of a message, and demonstrate a familiarity with the contents and format of a radiotelephone message.

9-23. How many format lines does radiotelephone employ?
1. 12
2. 14
3. 16
4. 18

9-24. What are the three major parts of a radiotelephone message?
1. Salutation, text, ending
2. Heading, text, ending
3. Salutation, text, closing
4. Heading, text, closing

9-25. Which of the following statements respecting the sequencing of information by format line on a radiotelephone (R/T) message is correct?
1. Its format and the format of the basic naval message are similar, but the format line containing the precedence precedes the addressees in one and follows the addressees in the other
2. Its format and the format of the basic naval message are similar, but the accounting information is assigned to different format lines in the two types of messages
3. Its format is of a completely different arrangement from that of a basic naval message
4. Its format order corresponds to the order of the basic naval message

496

Learning Objective: Describe the correct method of net contact when there is an exempt addressee, and demonstrate a familiarity with the composition of the time group and of prowords to be used on designated format lines.

Information for question 9-26: USS AUSTIN is net control on a net, the collective call of which is OVERWORK.

9-26. Which of the following is a correct call if the USS AUSTIN is calling all the members of the net EXCEPT USS STODDARD?

1. AUSTIN TO OVERWORK EXEMPT STODDARD
2. OVERWORK EXEMPT STODDARD FROM AUSTIN
3. OVERWORK, THIS IS AUSTIN, EXEMPT STODDARD
4. OVERWORK EXEMPT STODDARD, THIS IS AUSTIN

9-27. Which of the following responses contains only prowords which may be contained in the transmission instructions?

1. RELAY TO, WORDS TWICE, READ BACK, DO NOT ANSWER
2. EXEMPT, RELAY TO, WORDS TWICE, READ BACK
3. RELAY TO, WORDS TWICE, READ BACK, EXECUTE TO FOLLOW
4. WORDS TWICE, READ BACK, DO NOT ANSWER, EXECUTE TO FOLLOW

9-28. What proword precedes the spoken date-time group?

1. DATE-TIME GROUP
2. TIME
3. DATE-TIME
4. ZULU

9-29. What prowords identify the address portion of the message, and what is their correct sequence?

1. FROM, TO, INFO, EXEMPT
2. FROM, TO, EXEMPT, INFO
3. FROM, TO, INFO only
4. FROM, TO, ALL EXCEPT, INFO

9-30. What are the prowords for (a) prefixing the word group count, and (b) indicating that groups are NOT counted?

1. (a) GROUP COUNT, (b) GROUP NO COUNT
2. (a) GROUP NUMBER, (b) NO GROUP COUNT
3. (a) WORD GROUPS, (b) NO GROUP COUNT
4. (a) GROUPS, (b) GROUP NO COUNT

9-31. If it is necessary to clearly distinguish between the first two or last two sections of the R/T message to avoid confusion, what proword should be used?

1. BREAK
2. STOP
3. SLANT
4. END

9-32. It is 1601 on 21 October in your time zone, "S." You wish to send a time-group in format line 14, since it was impossible in this case to send the DTG earlier in the message. In which of the following ways could the required information be correctly expressed?

1. TIME ONE SIX ZERO ONE SIERRA TWO ONE OCTOBER
2. TIME TWO TWO ZERO ONE ZULU TWO ONE OCTOBER
3. TIME TWO ONE ONE SIX ZERO ONE SIERRA
4. TIME TWO ONE TWO TWO ZERO ONE ZULU

9-33. Which of the following responses contains only prowords which may be used in the "final instructions" line of an R/T transmission?

1. READ BACK, DO NOT ANSWER, WAIT, MORE TO FOLLOW
2. WAIT, CORRECTION, AUTHENTICATION IS, MORE TO FOLLOW
3. WAIT, DO NOT ANSWER, CORRECTION, EXECUTE TO FOLLOW
4. CORRECTION, DO NOT ANSWER, ACKNOWLEDGE, MORE TO FOLLOW

9-34. In transmissions in which the proword "DO NOT ANSWER" is used, what should be the ending proword(s)?

1. EXECUTE
2. OVER AND OUT
3. OVER
4. OUT

Learning Objective: Identify the normal frequency block and range of short-range and long-range R/T communications.

9-35. Within what frequency range is short-range operational radiotelephone communication normally conducted?

1. 2-32 MHz
2. 38-200 MHz
3. 225-400 MHz
4. 600-850 MHz

9-36. What is the normal transmission range of short-range operational radiotelephone communication?
1. 10-15 mi
2. 20-25 mi
3. 30-35 mi
4. 40-45 mi

9-37. Within what frequency range is long-range radiotelephone communication normally conducted?
1. 2-32 MHz
2. 38-200 MHz
3. 225-400 MHz
4. 600-850 MHz

Learning Objective: Identify the net usually used in port, point out where to find a list of the official voice call signs, and explain the proper procedures for identifying and checking into the net when in port.

9-38. Operational/tactical nets apply to most voice circuits used at sea. What is the name of the nets normally used in port?
1. General nets
2. Administrative nets
3. Harbor nets
4. Coastal nets

9-39. What publication contains a list of voice call signs designed to facilitate speed on tactical radio circuits?
1. ACP 100
2. JANAP 119
3. JANAP 128
4. NTP 9

9-40. By what call may a ship properly identify itself when entering a port which is NOT under U.S. control?
1. By the voice call signs it uses on tactical circuits
2. By the hull designation and number of the ship
3. By the name of the ship (usually last name only)
4. By the international call sign of the ship, spoken phonetically

9-41. The USS AUSTIN enters port in New London, CT, and desires to check into the local net normally used by ships in that harbor. In which of the following forms should the initial call be?
1. "NEW LONDON HARBOR, THIS IS AUSTIN, OVER"
2. "CONTROL, THIS IS AUSTIN, OVER"
3. "PORT CONTROL, THIS IS AUSTIN, OVER"
4. "HARBOR CONTROL, THIS IS AUSTIN, OVER"

Learning Objective: Describe the procedures of a free and a directed net and the responsibilities of net control and of other net members.

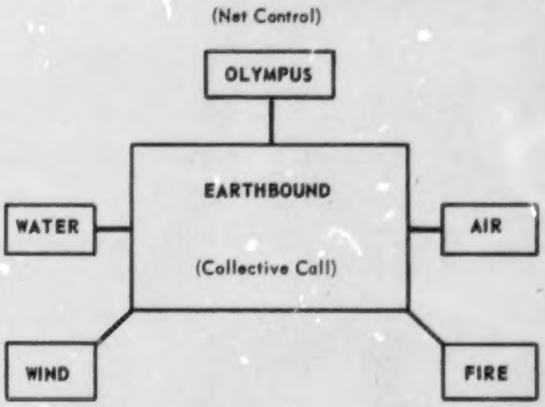


Figure 9A. - Radiotelephone net.

● Assume the existence of the net shown in figure 9A any time the name of one of the net members appears in questions 9-42 through 10-19. For questions 9-42 through 9-46, assume the net is a free net that has been temporarily closed.

9-42. Which of the following transmissions is a standard initial call for reopening the net?
1. "AIR, FIRE, WATER, WIND, THIS IS OLYMPUS, OVER"
2. "WIND FROM OLYMPUS, OVER"
3. "EARTHBOUND, THIS IS OLYMPUS, OVER"
4. "EARTHBOUND FROM OLYMPUS, THE NET IS OPEN, OVER"

9-43. The initial call to reopen this net has just been given by OLYMPUS. Which of the following would be a correct response to follow immediately?
1. "OLYMPUS, THIS IS AIR, OVER"
2. "OLYMPUS, AIR HERE, REPORTING IN TO NET, OVER"
3. "EARTHBOUND, THIS IS AIR, OVER"
4. "OLYMPUS, THIS IS AIR. I HAVE ONE PRIORITY FOR FIRE, AND ONE ROUTINE FOR WIND, OVER"

9-44. If, after OLYMPUS gives the initial call to reopen the net, AIR fails to respond, approximately how long should FIRE wait before giving a response?
1. Five seconds
2. Twenty seconds
3. Thirty seconds
4. One minute

9-45. AIR had transmission difficulty and could NOT answer OLYMPUS' reopening transmission. A few minutes after all the other stations responded in sequence, the problem was corrected. Which of the following calls should AIR now make?
1. "OLYMPUS, THIS IS AIR, OVER"
2. "OLYMPUS, THIS IS AIR REPORTING IN TO NET, OVER"
3. "EARTHBOUND, THIS IS AIR, OVER"
4. "EARTHBOUND, THIS IS AIR REPORTING IN TO NET, OVER"

9-46. OLYMPUS has reopened the net, all stations have responded, and OLYMPUS has acknowledged their transmissions. Which of the following could be a correct transmission to follow next?
1. "OLYMPUS, THIS IS AIR. I HAVE ONE PRIORITY AND ONE ROUTINE FOR FIRE AND ONE ROUTINE FOR WATER, OVER"
2. "EARTHBOUND, THIS IS AIR. I HAVE ONE PRIORITY AND ONE ROUTINE FOR FIRE AND ONE ROUTINE FOR WATER, OVER"
3. "FIRE, THIS IS AIR, OVER"
4. "FIRE, THIS IS AIR. I HAVE THE FOLLOWING MESSAGE TRAFFIC FOR YOU: ONE PRIORITY AND ONE ROUTINE, OVER"

● For questions 9-47 through 9-50, the net in figure 9A is a directed net that has been temporarily closed.

9-47. Which of the following is a standard call for reopening this net?
1. "AIR, FIRE, WATER, WIND, THIS IS OLYMPUS. THIS IS A DIRECTED NET. OF WHAT PRECEDENCE AND FOR WHOM ARE YOUR MESSAGES, OVER"
2. "EARTHBOUND, THIS IS OLYMPUS. THIS IS A DIRECTED NET. OF WHAT PRECEDENCE AND FOR WHOM ARE YOUR MESSAGES, OVER"
3. "EARTHBOUND, THIS IS OLYMPUS, OVER"
4. "EARTHBOUND, THIS IS OLYMPUS. THIS NET IS NOW OPEN, OVER"

9-48. The initial call has just been given by OLYMPUS to reopen the net. Which of the following could be a correct call to follow immediately?
1. "EARTHBOUND, THIS IS AIR, OVER"
2. "OLYMPUS, THIS IS AIR ACKNOWLEDGING NET OPEN, OVER"
3. "OLYMPUS, THIS IS AIR. I HAVE ONE IMMEDIATE FOR WATER AND TWO ROUTINE FOR WIND, OVER"
4. "OLYMPUS, THIS IS AIR, OVER"

9-49. Each station has traffic to transmit. Which of the following may be a correct transmission for OLYMPUS to make after all stations have responded to the initial reopening transmission?
1. "EARTHBOUND, THIS IS OLYMPUS, OUT"
2. "AIR, THIS IS OLYMPUS, ROGER. SEND YOUR IMMEDIATE, OVER"
3. "EARTHBOUND, THIS IS OLYMPUS, ROGER. SEND YOUR IMMEDIATE TRAFFIC, OVER"
4. "EARTHBOUND, THIS IS OLYMPUS, ROGER. AIR SEND YOUR IMMEDIATE, OVER"

9-50. Since the net reopened, all initial traffic has been cleared, and it has been fifteen minutes since anyone has transmitted on frequency. Which of the following may be a correct exchange of transmissions at this time?
1. "OLYMPUS, THIS IS WATER. I HAVE ONE IMMEDIATE FOR AIR, OVER" *** "THIS IS OLYMPUS. SEND YOUR MESSAGE, OVER"
2. "EARTHBOUND, THIS IS WATER. I HAVE ONE IMMEDIATE FOR AIR, OVER" *** "THIS IS AIR. SEND YOUR MESSAGE, OVER"
3. "AIR, THIS IS WATER. I HAVE ONE IMMEDIATE FOR YOU, OVER" *** "WATER, THIS IS AIR. SEND YOUR MESSAGE, OVER"
4. "AIR, THIS IS WATER, OVER" *** "WATER, THIS IS AIR, GO AHEAD, OVER"

Learning Objective: Describe the contents of and procedures used relative to the communications log.

9-51. Which of the following items should be included in the R/T circuit log?
1. Frequency adjustments and changes, causes of delay on the circuit, and changing of the watch
2. Frequency adjustments and changes, causes of delay on the circuit, and four-hour block counts of transmitted and received messages
3. Causes of delay on the circuit, changing of the watch, and the complete names and rates of personnel who have been assigned to communications within the past twenty-four hours
4. Frequency adjustments and changes, four-hour block counts of transmitted and received messages, and times of opening and closing by individual stations

9-52. When automatic recording devices are used to ensure a total record of traffic, the time should be recorded at intervals NOT exceeding how many minutes?
1. 10 min
2. 15 min
3. 3 min
4. 5 min

9-53. How should the operator correct an error in the log?
1. He should erase the error and write the correct entry in its place
2. He should put gummed tape over the error and write the correct entry in its place
3. He should draw a single line through the error, and write the correct entry adjacent to the original entry
4. He should type the correct entry on bond paper, cut it out, and glue it over the incorrect entry

---

Learning Objective: Describe correct procedures in transmitting easily confused words, encrypted groups, figures, dates, names, punctuation, and Roman numerals.

9-54. If part of a plain text message reads "TO AISHA LATER," how should the operator send this portion to facilitate correct receipt?
1. "TO ALFA-INDIA-SIERRA-HOTEL-ALFA LATER"
2. "TO AISHA, I REPEAT, AISHA LATER"
3. "TO AISHA, I SAY AGAIN, TO AISHA LATER"
4. "TO AISHA, I SPELL, ALFA-INDIA-SIERRA-HOTEL-ALFA, AISHA LATER"

9-55. In which of the following ways should an operator transmit the encrypted group "BRGSP"?
1. "BRAVO, ROMEO, GOLF, SIERRA, PAPA"
2. "B-R-G-S-P, I SAY AGAIN, B-R-G-S-P"
3. "I SPELL, B-R-G-S-P"
4. "I SPELL, BRAVO, ROMEO, GOLF, SIERRA, PAPA"

9-56. What are two correct ways of clearly distinguishing the number "two" from "to" or "too" in R/T communication?
1. "TWO, I SPELL, T-W-O" AND "NUMBERS TWO"
2. "TWO; THAT IS, T-W-O" and "NUMBERS TWO"
3. "FIGURES TWO" and "TWO, I SPELL, TANGO, WHISKEY, OSCAR, TWO"
4. "TANGO, WHISKEY, OSCAR" (no proword preceding) and "TWO, I SPELL, TANGO, WHISKEY, OSCAR, TWO"

● In questions 9-57 through 9-63, select the standard wording for radiocommunication transmission of the information given.

9-57. The number 1950.
1. WUN NINER FIFE OH
2. WUN NINER FIFE ZERO
3. WUN TOUZAND NINER FIFE ZERO
4. NINETEEN FIFTY

9-58. The number 705,000.
1. SEVEN OH FIFE COMMA ZERO ZERO ZERO
2. SEVEN HUNDRED FIFE TOUZAND
3. SEVEN ZERO FIFE ZERO ZERO ZERO
4. SEVEN ZERO FIFE TOUZAND

9-59. The number 68.7.
1. SIX EIGHT AND SEVEN TENTHS
2. SIXTY EIGHT DAY-SEE-MAL SEVEN
3. SIX EIGHT DAY-SEE-MAL SEVEN
4. SIX EIGHT POINT SEVEN

9-60. The date 24 March.
1. TOO FOWER M-A-R-C-H
2. TOO FOWER MARCH
3. TWENTY FOWER MARCH
4. TWENTY FOWER M-A-R

9-61. The name F. J. LANDRUM.
1. INITIALS, F-J LANDRUM
2. I SPELL, F-J LANDRUM
3. INITIALS, FOXTROT JULIETTE LANDRUM
4. I SPELL, FOXTROT JULIETTE LANDRUM

9-62. The punctuation (), when required.
1. PAREN, UNPAREN
2. PAREN, CLOSE PAREN
3. OPEN PARENTHESES, CLOSE PARENTHESES
4. OPEN PAREN, CLOSE PAREN

9-63. The Roman number IV.
1. INDIA VICTOR
2. ROMAN FOWER
3. ROMAN NUMERAL FOWER
4. ROMAN INDIA VICTOR

Learning Objective: Point out correct procedures in identifying by call sign, transmitting when call sign encryption is in effect, interrupting the carrier intermittently when transmitting, and testing the communication equipment over an R/T circuit.

9-64. At what times is it mandatory that a ship use its full or encrypted radiotelephone call sign?
1. Every time it transmits
2. When it checks into the net, and when it makes the first call of the day to any member of the net
3. On the first transmission after 0000 local time each day only
4. When a net is first established, and when the ship initially reports into an established net

9-65. If an operator is transmitting an R/T communication while call sign encryption is in effect, and sees that ship/unit names appear in the text, which of the following should he do?
1. He should transmit the text exactly as it is prepared
2. He should replace the ship/unit names with their encrypted call signs or address groups, preceded, if desired, by the proword CALL SIGN or ADDRESS GROUP
3. He should stop transmitting the message, send "DISREGARD THIS TRANSMISSION," and hold the message for transmission after call sign encryption is lifted
4. He should replace the ship/unit names with the code word CSEE (call sign encryption in effect), and furnish the actual names later after call sign encryption is lifted

9-66. Which of the following is the primary reason why an operator, while transmitting an R/T message, should pause and interrupt the carrier momentarily after each natural phrase?
1. To allow the receiving unit to break in, if desired
2. To make it more difficult for a hostile unit to pinpoint the exact location of the sending unit
3. To keep the transmission lines from overheating
4. To give the receiving operator time to catch up if he is behind

9-67. In the conduct of an equipment test on an R/T circuit, (a) what words are spoken for testing, and (b) what is the maximum time limit for the test?
1. (a) Numerals,
(b) 10 sec
2. (a) Numerals,
(b) 15 sec
3. (a) Letters, spoken phonetically,
(b) 15 sec
4. (a) The word "testing," repeated as desired,
(b) 10 sec

501

Learning Objective: Describe the correct sequence of net responses, and the procedures for radio, "WORDS TWICE," "READ BACK," transmission corrections, requests for retransmission of missed parts of messages, and message cancellation. (This objective is continued in Assignment 10.)

9-68. When abbreviated call signs are used on a net, in which of the following sequences should members of the net respond?
1. In alphabetic order according to the abbreviated call sign
2. In alphabetic order of the full call signs for which the abbreviations stand
3. In the order prescribed by net control, who is directed to assign an answering sequence in such circumstances
4. In the order prescribed by the current quarterly edition of the publication Net Procedures

9-69. The following transmission exchange takes place between AIR and WIND:
"WIND, THIS IS AIR. RADIO CHECK, OVER"
"AIR, THIS IS WIND, ROGER, OVER"
What is the meaning of the exchange?
1. AIR has informed WIND it is time for WIND's radio check, and WIND has acknowledged the call. AIR will now give WIND a report on signal strength and readability
2. AIR is requesting a radio check, and WIND has agreed to aid. AIR will now give a test call, after which WIND will give the signal report
3. AIR has requested that WIND give a report on AIR's radio signal, and WIND has agreed. WIND will make a second transmission to AIR within three minutes and give the report
4. AIR has requested WIND to give a report on AIR's signal. The omission of comment on signal strength and readability in WIND's reply informs AIR that the signal is satisfactory

9-70. Which of the following reports on signal strength and readability is in proper Navy R/T communications form?
1. "FOUR BY FOUR"
2. "FULL QUIETING"
3. "WEAK AND DISTORTED"
4. "SIGNAL STRENGTH 3, READABILITY 4"

- Because of poor communication conditions, OLYMPUS includes the prowords "WORDS TWICE" and "READ BACK" in a transmission to FIRE. Use the following as the alternatives for questions 9-71 through 9-74:

1. One time

2. Two times

3. None

9-71. How many times, if any, should OLYMPUS send the proword "THIS IS"?

9-72. How many times, if any, should OLYMPUS send the proword "WORDS TWICE"?

9-73. How many times, if any, should FIRE send the proword "ROGER"?

9-74. How many times, if any, should FIRE send each word of the text?

Assignment 10

Radiotelephone Procedures (Continued); Manual Teletypewriter Procedures

Textbook Assignment: Pages 267 - 285

Learning Objective: (Continued) Describe the procedures for transmission corrections, requests for retransmission of missed parts of messages, and message cancellation.

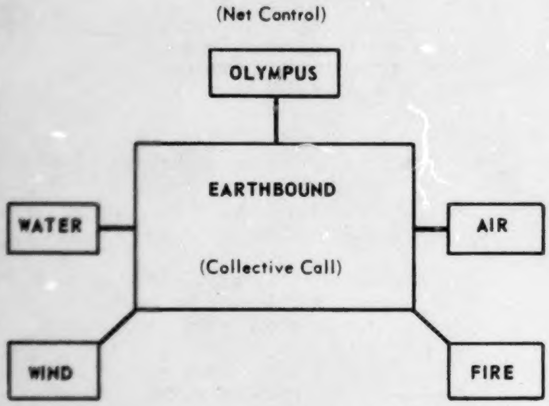


Figure 10A.

- In answering questions 10-1 through 10-19, refer to figure 10A.

10-1. An operator has just transmitted "USE TEST CHARLIE" as part of a message, and now realizes that the word sent as "TEST" is actually "TEXT." Which of the following transmissions is in the correct form for him to send next?
1. "CORRECTION, USE TEXT CHARLIE"
2. "CORRECTION. CHANGE TO USE TEXT CHARLIE"
3. "CORRECTION. TEXT VICE TEST"
4. "CORRECTION. STRIKE TEST, INSERT TEXT"

10-2. An operator on the AIR had received nearly an entire message from WIND when a loud noise occurred, causing him to miss the remainder. The last part of the text he received was "ADVISE IF ANY." Which of the following transmissions should he send?
1. "WIND, THIS IS AIR. REPEAT TEXT, OVER"
2. "WIND, THIS IS AIR. SAY AGAIN TEXT, OVER"
3. "WIND, THIS IS AIR. SAY AGAIN ALL AFTER ADVISE IF ANY"
4. "WIND, THIS IS AIR. SAY AGAIN ALL AFTER ANY, OVER"

10-3. An operator on board the FIRE was receiving a message from OLYMPUS, but missed the FROM, TO, and INFO portions. He received and copied the EXEMPT portion. How should he request the part he missed?
1. "OLYMPUS, THIS IS FIRE. SAY AGAIN ALL BEFORE EXEMPT"
2. "OLYMPUS, THIS IS FIRE. SAY AGAIN FROM TO EXEMPT, OVER"
3. "OLYMPUS, THIS IS FIRE. REPEAT FROM, TO, AND INFO, OVER"
4. "OLYMPUS, THIS IS FIRE. SAY AGAIN ZULU TO EXEMPT, OVER"

10-4. What should be transmitted to cancel (a) a message in process of being sent; and (b) a message that has been completely sent?
1. (a) The proword, "DISREGARD THIS TRANSMISSION, OUT;"
   (b) by separate message, "CANCEL MY ... (date-time group), OVER"
2. (a) The proword, "CANCEL THIS TRANSMISSION, OUT;"
   (b) by separate message, "DISREGARD MY ... (date-time group), OVER"
3. (a) The proword, "DISREGARD;"
   (b) by separate message, "DISREGARD MY ... (date-time group), OVER"
4. (a) The proword, "CANCEL;"
   (b) by separate message, "CANCEL MY ... (date-time group), OVER"

Learning Objective: Point out correct procedures for the receipt, acknowledgement, and verification of a message.

10-5. What are the prowords for (a) the receipt of a message, and (b) the acknowledgment of a message?
1. (a) RECEIVED; (b) WILCO
2. (a) ROGER; (b) WILCO
3. (a) ROGER; (b) ROGER, WILCO
4. (a) RECEIVED; (b) ROGER, WILCO

10-6. What do the prowords for (a) the receipt and (b) the acknowledgment of a message indicate?
1. (a) I have received and understand your last transmission;
   (b) I have received your signal, understand it, and will comply
2. (a) I have received your last transmission satisfactorily;
   (b) I have received your signal, understand it, and will comply
3. (a) I have received your last transmission satisfactorily;
   (b) I will comply within 24 hours
4. (a) I have received and understand your last transmission;
   (b) I will comply within 24 hours

10-7. In addition to the commanding officer, who is/are authorized to initiate an acknowledgment for a message?
1. The communications officer and the assistant communications officer
2. The commanding officer's authorized representative and the communications officer
3. The commanding officer's authorized representative and the operations officer
4. The commanding officer's authorized representative only

10-8. If an operator receives a request to verify part of a message, he should find it and check the cryptography (if it is encrypted). What else should he always do before transmitting the verification of the message?
1. Verify his reading of the message with the senior enlisted person in communications
2. Verify his reading of the message with the communications officer
3. Verify the message with the person who originated it
4. Ask the requesting operator specifically which word(s) he suspects is/are in error in order that he may check more specifically

---

Learning Objective: Name the general types of authentication and describe procedures for breaking in on a net in order to send FLASH messages, for using the delayed executive and immediate executive method, and for imposing emergency silence.

● Assume the following situation in questions 10-9 and 10-10: WATER is sending ROUTINE messages to WIND. The operator on the FIRE is given a FLASH message for AIR.

10-9. If the units named are operating on a free net, the operator on the FIRE should break in and make what transmission?
1. "AIR, AIR, AIR, THIS IS FIRE. I HAVE ONE FLASH FOR YOU, OVER"
2. "AIR, AIR, AIR, THIS IS FIRE, FLASH, OVER"
3. "FLASH, FLASH, FLASH. AIR, THIS IS FIRE, FLASH, OVER"
4. "FLASH, FLASH, FLASH. AIR, THIS IS FIRE. I HAVE ONE FLASH FOR YOU, OVER"

10-10. If the net is directed, the operator on the FIRE should make what transmission?
1. "OLYMPUS, OLYMPUS, OLYMPUS, THIS IS FIRE. I HAVE ONE FLASH FOR AIR, OVER"
2. "FLASH, FLASH, FLASH, OLYMPUS, THIS IS FIRE, FLASH FOR AIR, OVER"
3. "FLASH, FLASH, FLASH, OLYMPUS, THIS IS FIRE, REQUEST PERMISSION TO SEND ONE FLASH TO AIR, OVER"
4. "AIR, AIR, AIR, STAND BY FOR FLASH. OLYMPUS, THIS IS FIRE, OVER"

10-11. Which of the following transmissions is in the correct format to impose emergency silence?
1. "EARTHBOUND, THIS IS OLYMPUS, SILENCE, SILENCE, SILENCE, OUT"
2. "EARTHBOUND, THIS IS OLYMPUS, EMERGENCY SILENCE, SILENCE, SILENCE, OUT"
3. "EARTHBOUND, THIS IS OLYMPUS, EMERGENCY SILENCE, SILENCE, SILENCE, TIME ONE ONE THREE EIGHT ZULU, OUT"
4. "EARTHBOUND, THIS IS OLYMPUS, SILENCE, SILENCE, SILENCE, TIME ONE ONE THREE EIGHT ZULU, OUT"

10-12. Which of the following is a correct example of a tactical message sent by the delayed executive method?
1. "EARTHBOUND, THIS IS OLYMPUS, SHIFT YOUR RUDDER, STAND BY TO EXECUTE, OVER"
2. "EARTHBOUND, THIS IS OLYMPUS, DELAY EXECUTE, SHIFT YOUR RUDDER, OVER"
3. "EARTHBOUND, THIS IS OLYMPUS, EXECUTE TO FOLLOW, SHIFT YOUR RUDDER, OVER"
4. "EARTHBOUND, THIS IS OLYMPUS, DEFER EXECUTION, SHIFT YOUR RUDDER, OVER"

10-13. The executive signal that follows a delayed executive transmission can correctly be exemplified in which of the following ways?
1. "EARTHBOUND, THIS IS OLYMPUS. STAND BY, EXECUTE, FIRE, OVER"
2. "EARTHBOUND, THIS IS OLYMPUS. PREPARE, EXECUTE, FIRE, OVER"
3. "EARTHBOUND, THIS IS OLYMPUS. THREE-TWO-ONE-EXECUTE, FIRE, OVER"
4. "EARTHBOUND, THIS IS OLYMPUS. EXECUTE, FIRE, OVER"

10-14. Following is an example of the beginning of a message sent in the immediate executive method: "EARTHBOUND, THIS IS OLYMPUS, IMMEDIATE EXECUTE, BREAK, SHIFT YOUR RUDDER." Which of the following endings is in the correct format?
1. "FIRE, WATER, EXECUTE, OVER"
2. "I REPEAT, SHIFT YOUR RUDDER, EXECUTE, FIRE, WATER, OVER"
3. "I SAY AGAIN, SHIFT YOUR RUDDER, EXECUTE, FIRE, WATER, OVER"
4. "I SAY AGAIN, SHIFT YOUR RUDDER, STAND BY, EXECUTE, FIRE, WATER, OVER"

10-15. Generally speaking, what are the two types of authentication?
1. Challenge and reply, and transmission
2. Password response and transmission
3. Challenge and reply, and code key
4. Password response and code key

Learning Objective: State the conditions under which enemy contacts are made more than once, describe the correct procedures for transmitting code words, state the proword to precede the transmission of flag signals, and give the term for the standard words and phrases used to standardize and speed transmissions.

10-16. Reports of enemy contacts are normally to be made only once when you are in direct communication with the Officer in Tactical Command (OTC), a higher authority, or a shore radio station. Under what two conditions are enemy contact reports made more than once?
1. When "DO NOT ANSWER" procedures are used; when the text consists of emergency alarm signals
2. When the text consists of emergency alarm signals; when adverse weather conditions prevail
3. When "DO NOT ANSWER" procedures are used; when adverse weather conditions prevail
4. When it seems likely the enemy is preparing to attack; when "DO NOT ANSWER" procedures are used

10-17. What is the proword(s) used on administrative nets to precede the transmission of flag signals?
1. "FLAG SIGNALS"
2. "FLAG"
3. "SIGNALS"
4. "FLAGSIGS"

10-18. What is the proper term for the words and phrases used in radiotelephone to standardize the vocabulary, increase accuracy, and shorten the time of transmission when messages are sent that relate to such specialized subjects as tactical maneuvering, electronic countermeasures, air control, etc.?

1. Standard tactical code
2. Standard short forms
3. Operational short forms
4. Operational brevity codes

Learning Objective: Select the publications recommended for increasing proficiency as an R/T communications operator.

10-19. One of the best times to know and the worst times to look up proper communications procedures is when the operational situation is critical and requires quick action. The last part of chapter 12 of your textbook recommends the careful study of two publications and part of a third to enhance the skill of radiotelephone operators. Which publications are they?

1. ACP 125, ACP 165, and part of ATP 1
2. NWP 4, NWP 33, and part of KAG 1
3. CMS 4, KAG 1, and part of ACP 125
4. ACP 122, ACP 125, and part of ACP 165

Learning Objective: Identify a publication that contains detailed information pertaining to manual teletype procedure, and explain the purpose and usage of various teletype machine functions.

10-20. Which of the following publications contains detailed information concerning basic teletype machine functions, operating instructions, and procedures associated with manual teletype procedure?

1. ACP 100
2. ACP 113
3. ACP 124
4. ACP 126

10-21. If "(FIG) 45573 (SP) 28763" is transmitted on a Navy teletype, how would it be received on (a) a commercial teletypewriter exchange teletype (TWX) and (b) a Navy teletype?

1. (a) 45573 28763, (b) 45573 WIUYE
2. (a) 45573 WIUYE, (b) 45573 28763
3. (a) 45573 28763, (b) 45573 28763
4. (a) 45573 WIUYE, (b) 45573 WIUYE

10-22. How would "(FIGS) 17642 (SP) WRITE," transmitted on a TWX teletype, be received on (a) a TWX teletype and (b) a Navy teletype?

1. (a) 17642 WRITE, (b) 17642 24853
2. (a) 17642 24853, (b) 17642 WRITE
3. (a) 17642 24853, (b) 17642 24853
4. (a) 17642 WRITE, (b) 17642 WRITE

10-23. How should you transmit "14860 27539" on (a) a Navy teletype and (b) a TWX teletype?

1. (a) (FIGS) 14860 (SP) (FIGS) 27539,
   (b) (FIGS) 14860 (SP) (FIGS) 27539
2. (a) (FIGS) 14860 (SP) 27539,
   (b) (FIGS) 14860 (SP) 27539
3. (a) (FIGS) 14860 (SP) (FIGS) 27539,
   (b) (FIGS) 14860 (SP) 27539
4. (a) (FIGS) 14860 (SP) 27539,
   (b) (FIGS) 14860 (SP) (FIGS) 27539

10-24. Why should the carriage return (CR) be pressed twice rather than just once?

1. To provide a second chance for the mechanism to engage, should it fail to do so the first time
2. To allow sufficient time for the carriage to return all the way to the left margin before typing resumes
3. Because the machine design by the manufacturer is such that some functions are initiated by a single stroke, and others, including CR, by a double stroke
4. Because it takes one stroke for the carriage to go back and one stroke for the paper to turn up to the next line

In questions 10-25 through 10-28, select from column B the teletype functions associated with the actions listed in column A.

A. Actions

10-25. The advancement of blank tape through the punch block of the teletype perforator

10-26. The changing of upper or lower case to the opposite

10-27. The advancement of the paper up the page

10-28. The advancement of the carriage (type box) to the right without printing

B. Teletype Functions

1. Line feed (LF)
2. Space (SP)
3. Blank (BL)
4. Shift/unshift

10-29. To attract the attention of the receiving operator, the sending operator should activate the bell signal by sending which of the following transmissions?
1. (FIGS) JSJSJSJSJS (LTRS)
2. (FIGS) JJJJJSSSSS (LTRS)
3. (FIGS) JJJJJ (SP) (FIGS) SSSSS (LTRS)
4. (FIGS)J(SP)J(SP)J(SP)J(SP)J(SP) S(SP)S(SP)S(SP)S(SP)S(LTRS)

10-30. What type of equipment utilizes (a) a warning light and (b) a margin bell to indicate the approach of the end of the typing line?
1. Both (a) and (b), page printers with direct line operation capabilities
2. Both (a) and (b), tape perforating equipment
3. (a) Tape perforating equipment, (b) page printers with direct line operation capabilities
4. (a) Page printers with direct line operation capabilities, (b) tape perforating equipment

10-31. What are the alignment functions that must precede all message transmissions?
1. 3SP, 2CR, 2LF
2. 5SP, 2CR, 2LF
3. 5SP, 2CR, 1LF
4. 8SP, 2CR, 1LF

10-32. What is the correct procedure for returning the carriage and placing it in the proper position for the next line of text?
1. 3CR only
2. 2CR, 2LF
3. 3CR, 1LF
4. 2CR, 1LF

10-33. What is the function group used between pages of a long message?
1. 2CR, 2LF, 12LTRS
2. 3CR, 2LF
3. 2CR, 4LF only
4. 2CR, 4LF, NNNN

10-34. What is the standard group of functions that comprise the end of message (EOM) functions?
1. 2CR, 8LF, NNNN, 12LTRS
2. 2CR, 8LF, NNNN, 6LTRS
3. 2CR, 12LF, NNNN only
4. 2CR, 12LF, NNNN, 12LTRS

10-35. What is the standard maximum number of characters, including spaces, for each line?
1. 63
2. 65
3. 67
4. 69

Learning Objective: Specify the authorized abbreviations and symbols for message punctuation.

10-36. Which of the following alternatives contains either an abbreviation or a symbol that is NOT authorized for teletype transmission?

	Abbreviations	Symbols
1.	QUES	?
2.	HPHN	-
3.	CLN	:
4.	PAREN	()

10-37. Which of the following alternatives contains either an abbreviation or a symbol that is NOT authorized for teletype transmission?

	Abbreviations	Symbols
1.	PD	.
2.	CMM	,
3.	SLANT	/
4.	QUOTE-UNQUOTE	"

10-38. Which of the following statements concerning the use of "X" as punctuation in messages is correct?
1. It is mandatory that "X" be used as punctuation at a specified point in each message, but this is the only point at which it may be used
2. The letter "X" may be used when exact punctuation is not required, and no ambiguity will result from its use
3. At one specified point the phonetic form "X-RAY" must be used, and throughout the message "X-RAY" is a more acceptable form of punctuation than "X"
4. The use of "X," either as a single-letter or phonetic form, as punctuation is forbidden

---

Learning Objective: Explain the format of basic teletypewriter messages.

10-39. What publication gives detailed usages of format line 1 with reference to tape relay procedures?
1. ACP 127
2. JANAP 128
3. NTP 3
4. NWP 4

10-40. Which of the following is NOT an approved use of format line 1?
1. For "pilots" (message handling instructions) and for "pilot cards" containing special handling instructions in data communications
2. For transmission identification (TI), normally channel numbers, and for start of message (SOM) indicators
3. For indicators of the inclusion of foreign language words
4. For use in specified AUTODIN methods of operation

Learning Objective: Describe or identify procedures for manual teletype (TTY) calling, answering, and testing.

In items 10-41 through 10-43, select from column B the name of the type of call shown in column A. (NNBD and NFGO are single stations; HZDQ is a collective call including several stations.)

	A. Calls	B. Types of Calls
10-41.	NNBD DE NFSK K	1. Single call
10-42.	HZDQ DE NFSK K	2. Multiple call
10-43.	NNBD NFGO DE NFSK K	

10-44. NBCR wants to send a TTY message to action addressees NMJQ and NKYP, and to information addressees NBBW and NKQY. Which of the following should appear in the message? (Machine functions are NOT shown.)
1. ACT NMJQ NKYP DE NBCR
   INFO NBBW NKQY DE NBCR K
2. NMJQ NKYP FM NBCR
   ZFH2 NBBW NKQY FM NBCR K
3. NMJQ NKYP DE NBCR
   NBBW NKQY
4. NMJQ NKYP NBBW NKQY DE NBCR
   ZFH2 NBBW NKQY

10-45. Which, if any, of the following statements is correct relative to the following example, received as part of a TTY message?

(5SP)(2CR)(LF)
NMJQ NRSV NBBW DE NBCR (2CR)(LF)
ZFH2 (2CR)(LF)

1. NMJQ, NRSV, and NBBW are all information addressees
2. NMJQ, NRSV, and NBBW are action addressees; ZFH2 is a transmission instruction connected with format line 4
3. NMJQ, NRSV, and NBBW are action addressees; ZFH2 is an information addressee
4. The last two addressees, NRSV and NBBW, are information addressees, as indicated by the "2" in "ZFH2"

10-46. HZDQ has just initiated a call to NBBW. How should NBBW answer?
1. (5SP)(2CR)(LF)
   NBBW K (2CR)(LF)
2. (5SP)(2CR)(LF)
   HZDQ DE NBBW K (2CR)(LF)
3. (5SP)(2CR)(LF)
   HZDQ DE NBBW GO AHEAD K
4. (5SP)(2CR)(LF)
   HZDQ DE NBBW STANDING BY K

10-47. HZDQ has called NBBW, and NBBW has answered. What machine function should HZDQ execute prior to sending the message?
1. (5SP)(2CR)(LF)
2. (2CR)(8LF) only
3. (5SP)(2CR)(8LF)
4. (5SP)(2CR)(2LF)

10-48. If a station fails to answer in proper sequence when a multiple call is made, how long should the next station wait before responding?
1. 5 sec
2. 10 sec
3. 15 sec
4. 20 sec

10-49. In a net of six stations, if the station that should have answered first is NOT able to answer, but clears its problem just as the third station answers, which of the following procedures should the first station follow?
1. It should answer between the third and fourth stations
2. It should answer between the last two stations
3. It should wait five seconds after the last station answers, transmit the bell signal, and then answer
4. It should answer within five seconds after the last station responds

10-50. A certain circuit has just opened after experiencing difficulty. NBCR correctly conducts a standard test. He first transmits (5SP)(2CR)(LF). Which of the following may be the next part of his transmission?
1. THIS IS A TEST
2. HZDQ DE NBCR
3. NBCR TESTING
4. TEST HZDQ DE NBCR

Learning Objective: Describe various procedures relative to ending prosigns and message precedence.

10-51. When a message transmission ends with "AR," may a station, in accordance with regulations, (a) receipt for the message, and (b) request a verification?
1. Both (a) and (b), no
2. (a) No, (b) yes
3. (a) Yes, (b) no
4. Both (a) and (b), yes

10-52. In duplex operation, when, if ever, should messages being transmitted be interrupted to respond to received messages?
1. Any time the received message is of higher precedence than the message being transmitted
2. Only when the received message is of FLASH precedence and the message being transmitted is of lower precedence
3. Only when the received message is of IMMEDIATE precedence or higher and the message being transmitted is of lower precedence
4. Never

10-53. If a string of messages is being transmitted, when should responses ordinarily occur?
1. After the last message only
2. After every fifth message and the last message
3. After every third message and the last message
4. After each message

10-54. If multiple-page messages are being transmitted, when should responses be made?
1. After the last page only
2. After every third page and the last page
3. After every second page and the last page
4. After each page

10-55. Whose responsibility is it to assign the precedence to a TTY message?
1. The originator of the message
2. The communications officer
3. The senior enlisted man in communications
4. The Classified Material Control Officer

10-56. A message is being sent to NBAT for action and NFWS for information. Its precedence is IMMEDIATE to NBAT and PRIORITY to NFWS. Which of the following precedence entries is correct?
1. O ACT P INFO
2. O P INFO
3. OP
4. O P

10-57. Which, if any, of the following explanations gives the correct meaning of the following initial call?

(5SP)(2CR)(LF)
NBAT DE NFWS ZBO3 O P R K (2CR)(LF)

1. NFWS, identified by ZBO3 as the third station to respond on the net, has messages of O, P, and R precedence for NBAT
2. NFWS is sending the same message to three action addressees. It is O precedence to those required to reply, P to other action addressees, and R to info addressees
3. NFWS has three messages for NBAT, these having precedences O, P, and R
4. NFWS has an unspecified number of messages of precedences O, P, and R for NBAT

10-58. On simplex circuits, what is the standard transmission used to interrupt message traffic for a FLASH message?
1. (FIGS) A (FIGS) A (FIGS) A
2. (LTRS) Z (FIGS) JS (LTRS) Z (FIGS) JS
3. (FIGS) JJJJJSSSSS
4. (FIGS) JSJSJSJSJS

Learning Objective: Describe correct procedures for correcting teletype errors when a unit is in direct communication with another unit, and also when it is preparing tape for transmission.

10-59. During manual transmission of a message text, an operator, attempting to send "PERFORM ALL DUTIES," sent "PERFORM ALL DTUIES." Being aware of his error, what should he send next?
1. (FIGS) A (FIGS) A (FIGS) A (LTRS) ALL DUTIES
2. (FIGS) JJJJJSSSSS (LTRS) ALL DUTIES
3. (FIGS) JJJJJSSSSS (LTRS) EEEEEEEE ALL DUTIES
4. EEEEEEEE ALL DUTIES

Judge whether questions 10-60 through 10-63, relating to correcting teletype errors, are True or False.

10-60. When tape is being prepared for transmission, an error in the text may be corrected by backspacing the tape, striking the LTRS key to block out the error, and then retyping.

10-61. When tape is being prepared for transmission, an error in the heading may be corrected by backspacing the tape, striking the LTRS key to block out the error, and then retyping.

10-62. When the unit is in direct communication with another unit, an error in the heading may be corrected by using the error prosign, repeating the last prosign or operating signal correctly sent, and continuing.

10-63. If an operator sent "READY CORRECTION" vice "READY CONNECTION" in the text but did not notice it until later, he may properly correct it at the end of the message in this way:

(......Text of message)(2CR)(LF)
BT (2CR)(LF)
C WA READY - CONNECTION (2CR)(LF)
(...Operating signals and prosigns as required).

10-64. While preparing a tape for transmission, an operator made a mistake on the second page of a four-page message. He was on the fifth line down from the error (and two lines from the end of the page) when he realized his mistake. Where should he correct it?

1. Immediately after the line he is transmitting now
2. Starting at the location of the error. Go back and LTR out all characters from the place the error was made
3. At the bottom of the page on which the error occurred
4. At the end of the message

● In questions 10-65 through 10-67, assume that correct operation signals are included. They have been omitted for the sake of simplicity.

10-65. NABC received a message from NZYX, the text of which began as follows:

"ONE P3C AIRCRAFT AND TWO S2 AIRCRAFT
EWXWNTLY ARRIVED ..."

The word received as "EWXWNTLY" should be "RECENTLY." If NABC transmits "NZYX DE NABC IMI WA AIRCRAFT," what answer should he receive?

1. NABC DE NZYX WA AIRCRAFT RECENTLY K
2. NABC DE NZYX WA AIRCRAFT RECENTLY VICE EWXWNTLY K
3. NABC DE NYZX EEEEEEEE AIRCRAFT RECENTLY K
4. NABC DE NZYX WA AIRCRAFT AND K

Learning Objective: Describe procedures for questioning words or groups in messages, repeating or asking for repetitions, and handling messages when unable to get immediate corrections.

10-66. What is the correct procedure for NABC to use to request NZYX to repeat the sixth group of an encrypted message?

1. NZYX DE NABC IMI 6 K
2. NZYX DE NABC IMI SIX K
3. NZYX DE NABC IMI SIXTH K
4. NZYX DE NABC IMI GRP 6 K

10-67. If NBQD receives the transmission,

NBQD DE NPVD IMI BT TO BT K,

what part of the message should he retransmit?

1. The text only
2. All except the text
3. The heading and the text
4. The heading only

10-68. If an operator receives a medium-length message of O precedence for forwarding, but it has one garbled word for which he is unable to obtain a correction or repetition immediately, what should he do?

1. He should hold the message until he gets a correction
2. He should forward the message, subject to correction (SUBCOR) immediately, and then send the correction when he can obtain it
3. He should forward the message immediately, and include the proword "CORFOL" (correction follows) to notify the recipient that he will forward the correction when he can obtain it
4. He should forward the message, and advise the recipient by the proword "NOCOR" that he was NOT able to receive a correction

Learning Objective: Explain the meanings of "J," eight "E"s followed by "AR," and "INT GR9"; count the groups in a text; and identify the correct formats for transmitting group count checks for plaintext and encrypted messages.

10-69. What does the prosign "J" mean?

1. Retransmit last message. Experiencing equipment trouble
2. Wait five minutes before transmitting. Equipment down
3. I have received your message and am ready to continue
4. Verify with the originator and repeat

10-70. An operator is receiving the text of a message when suddenly he receives eight Es separated by spaces and followed by "AR." What does this mean?
1. The sender has equipment trouble. He will send the message again later
2. There is an apparent discrepancy between the classification of the message and its contents
3. The message is canceled
4. The sending unit must clear all machines of traffic until the accounting data for the past twenty-four hours is collected

10-71. What is the group count of the following text?

INITIATE SECOND PHASE OF PROJECT
CRTZOF X RULNAX REPORT DUE
THIRTEENTH X EXPECT INTERVIEW
AT SALTLAKECITY OR SANDIEGO

1. 16
2. 18
3. 19
4. 21

10-72. What is the meaning of the following transmission?

(5SP)(2CR)(LF)
NOKB DE NFSK INT GR9 K
(2CR)(LF)

1. Is the group count, indicated as "9," correct?
2. Repeat the 9th group
3. Verify group 9
4. Sender was interrupted, but will resume sending with group 9

In questions 10-73 through 10-75, select from column B the transmission format in which the group count checks of the types of message specified in column A should be transmitted. Assume operating signals are correctly included in column B.

	A. Types of message	B. Formats
10-73.	Plaintext message, over 50 words	1. NABC DE NZYX GR (number in group) BT D P R C(...etc.) BT K
10-74.	Encrypted message, over 50 words	2. NABC DE NZYX GR (number in group) BT DRAW POWER RECORDS (...etc.) BT K
10-75.	Plaintext or encrypted message, 50 words or less	3. NABC DE NZYX GR (number in group) BT 1-D 11-R 21-S 31-M(... etc.) BT K
		4. NABC DE NZYX GR (number in group) BT 1-D 6-C 11-R 16-F (... etc.) BT K

Assignment 11

Manual Teletypewriter Procedures (Continued); Automated Systems

Textbook Assignment; Pages 286 - 305

Learning Objective: Describe correct format procedures for placement of words on a line, lines on a page, and division of messages into multiple pages and multiple increments.

11-1. In teletype messages, may a word be hyphenated at the end of a line?
1. Yes
2. Yes, if, and only if, it is at least nine letters long
3. Yes, if, and only if, it is at least twelve letters long
4. No

11-2. What is the maximum number of lines, counting from format line 5 of the heading, the first page of a message may contain without being divided into pages for transmission?
1. 15
2. 18
3. 20
4. 25

11-3. What is the maximum number of pages of message text allowed in one transmission, disregarding any page containing both heading and text?
1. 7
2. 6
3. 5
4. 4

11-4. How many lines must be contained on the second and each succeeding page of a multiple-page message, excluding the last page?
1. 15
2. 18
3. 20
4. 25

11-5. Long messages are sometimes divided into increments for transmissions. What is the name of these segments?
1. Dispatch segments
2. Transmittal increments
3. Transmission sections
4. Communication installments

11-6. A certain unencrypted message has been divided into three parts for transmission. How should the parts be identified?
1. SECTION 1, SECTION 2, SECTION 3
2. SECTION 1 OF 3, SECTION 2 OF 3, SECTION 3 OF 3
3. SECTION 1 OF 3, SECTION 2 OF 3, FINAL SECTION OF 3
4. 1ST SECTION OF 3, 2ND SECTION OF 3, FINAL SECTION OF 3

11-7. Does each increment of a message that has been divided for transmission have the same or different (a) station serial number(s), and (b) date-time group(s)?
1. (a) Same, (b) different
2. Both (a) and (b), same
3. Both (a) and (b), different
4. (a) Different, (b) same

Learning Objective: Explain the meanings of various prosigns, group count reports, and operating signals.

In questions 11-8 through 11-11, select from column B the prosign associated with the meaning given in column A.

	A. Meanings	B. Prosigns
11-8.	Repeat back	1. AS
11-9.	More to follow	2. B
11-10.	Action on the message or signal which follows is to be carried out upon receipt of "EXECUTE"	3. G
		4. IX
11-11.	Wait	

11-12. On a transmission which NABC received from NZYX, the last line in the heading reads
GR190 (2CR)(LF).
The last two lines of the transmission read
B100 (2CR)(LF)
K (2CR)(4LF).
How many groups of this message are still to be transmitted?
1. 10
2. 90
3. 100
4. 190

11-13. What does "ZUG HM HM HM" mean?
1. The sending unit is requesting an immediate check to find out if its transmissions are garbled
2. All units stand by for emergency message
3. Maintain emergency silence
4. Emergency silence is lifted

11-14. The first part of a transmission reads as follows:
(5SP)(2CR)(LF)
NABC DE NZYX (2CR)(LF)
T NFJL (2CR)(LF)
P 221410Z AUG 78 (2CR)(LF)
What is the meaning of the "T"?
1. NZYX will transmit the same message to NFJL
2. NABC is to transmit the message to NFJL
3. Time is critical in passing the message to NFJL
4. The message is applicable to NFJL for a temporary time

Learning Objective: Give the location of manual switching procedures, explain various manual switching procedures, and identify standard phraseology used in switchboard operation.

11-15. What does the operating signal "ZWL" mean?
1. "Double relay." Messages designated for addressees specified after "ZWL" must pass through two relay stations
2. The addressee specified after ZWL is required to reply within six hours
3. No forwarding action is required to the addressee specified after ZWL
4. The replies from all other addressees are to be sent to the addressee specified after "ZWL," who will consolidate them and send one reply

11-16. The National Annex to what publication contains the manual switching procedures used by each nation?
1. ACP 100
2. ACP 113
3. ACP 126
4. JANAP 128

11-17. If your teletype unit works through a switchboard, how should you call the switchboard operator?
1. Activate the bell signal, and sound five bells
2. Send "RYRYRYRYRY"
3. Transmit "SWITCH DE (your call)"
4. Depress the "BREAK" switch for two seconds

11-18. If NABC has an O precedence message for NZYX, what transmission should NABC send to the switchboard operator on the preliminary call?
1. "NABC ONE O FOR NZYX K"
2. "NXYX DE NABC O K"
3. "SWITCH DE NABC O FOR NZYX K"
4. "SWITCH NZYX DE NABC ONE O K"

11-19. After sending the message, what transmission should NABC make to terminate the switchboard connection?
1. "SWITCH DE NABC AR"
2. "DE NABC AR"
3. "SWITCH TERMINATE NABC AR"
4. "TERMINATE NABC AR"

In questions 11-20 through 11-22, select from column B the standard term the switchboard uses in the situation given in column A.

	A. Situations	B. Terms
11-20.	NABC has called the switchboard operator and sent the preliminary call. The switchboard operator responds, "Your call has been ________"	1. Confirmed 2. Booked 3. Tabled out 4. Engaged
11-21.	After the switchboard operator makes contact with the called station, he tells NABC, "The station called is ________"	
11-22.	If switching arrangements can NOT be made through existing trunk connections or are NOT considered practicable for further switching, the messages are ________"	

Learning Objective: Describe briefly and generally, the name, organization, and advantages/disadvantages of AUTODIN, and the function of Automatic Switching Centers (ASCs).

11-23. For what does the acronym "AUTODIN" stand?
1. Automatic Directed Network
2. Automated Distribution Network
3. Automatic Digital Network
4. Automated Digital Network

Questions 11-24 through 11-27, related to AUTODIN, are to be judged True or False.

11-24. AUTODIN is managed by the Federal Communications Commission.

11-25. AUTODIN has the advantages of reliability and speed, but its lack of flexibility in interfacing with various computer languages, equipment, media, and speeds is a serious disadvantage.

11-26. The function of the Automatic Switching Centers (ASCs) is to accept messages from subscribers, determine their classifications and precedences, and relay them to the subscribers to whom they are addressed.

11-27. The ASCs are the focal points of the entire AUTODIN system.

Learning Objective: Identify the basic types of languages used by AUTODIN, and distinguish among the operational modes available.

To answer questions 11-28 through 11-30, select from column B the name of the language that matches the description shown in column A.

	A. Descriptions	B. Languages
11-28.	Eight-level paper tape	1. ASC II Code
		2. Hollerith Code
11-29.	Five-level paper tape	3. ITA #2 Code
11-30.	Standard punch card language	

11-31. What name is given to the following method of channel operation: A duplex operation with automatic error and channel controls allowing independent and simultaneous two-way operation?
1. Mode I
2. Mode II
3. Mode III
4. Mode IV

Learning Objective: Explain the timing system in AUTODIN equipment, and define terms used in the AUTODIN system.

11-32. In which of the following ways does the timing system work, insofar as message delivery is concerned?

1. As a switching center receives messages addressed to each of various terminals, the timing system connects the ASC to the terminals in the same sequence in which messages were received so that they may be delivered
2. It briefly connects a switching center to each terminal in turn, and at each connection any messages which are awaiting delivery to that terminal are transmitted
3. It briefly connects a switching unit to each terminal in turn, except that terminals for whom there is no traffic will be "passed over" (no connection made) any time there is a complete message awaiting transmittal
4. As each terminal calls in, in a prescribed sequence, to request its messages, the timing device effects the release and automatic transmission of messages for that terminal

11-33. What is a journal, and for what is it used?

1. It is a brief daily message report to the headquarters in charge of AUTODIN to report the number of messages sent and received at a particular ASC during the last twenty-four hours
2. It is a brief, concise list of operating instructions used for the indoctrination of new AUTODIN subscribers
3. It is a copy of an incoming message, in its entirety, and is used for reference as necessary
4. It is a copy of the address only of an incoming message, and is used as an index to locate the reference copy

---

Learning Objective: Explain the configuration, functions, and operation of Digital Subscriber Terminal Equipment (DSTE).

11-34. DSTE may be configured as which of the following?

1. Only as a card terminal
2. Only as a tape terminal
3. As either a card or a tape terminal, but not as a combination
4. As a card or a tape or a combined card and tape terminal

11-35. What is the function of the common control unit (CCU)?

1. To accept data characters as input, accumulate them into data blocks in memory, and distribute data blocks as output
2. To accept data characters as input; print output on single, 2, 3, 4, and 5 multiple paper or multilith or ditto masters; and retain data in memory for farther utilization
3. To accept data characters from cards or paper tape in any of three codes, and do necessary conversion, output characters in ASC II
4. To serve only as a central unit to start, stop, and coordinate all peripheral equipment

11-36. What is the function of the card reader?

1. To read cards punched in ASC II characters, change them to Hollerith code, and transfer data to CCU
2. To read cards punched in Hollerith code, change them to ASC II code, and transfer data to CCU
3. To read cards punched in Hollerith code, print on each card the information punched in it, and stack cards for further use
4. To read cards punched in any code, convert them to Hollerith code, and transfer the data to the page printer

11-37. What is the function of the paper tape reader?

1. To convert the perforations to electrical data in the ITA #2 code and transfer the data to the CCU
2. To transmit the data contained in the paper tape to a switching unit for relay
3. To convert the paper perforations to Hollerith code and transfer the data to the high-speed card punch
4. To convert the paper perforations to electrical data in the ASC II code, and transfer the data to the CCU

11-38. What is the function of the high- and low-speed card punches?
1. To accept data from the universal keyboard only, and punch cards in Hollerith code
2. To accept data in ASC II code from the CCU (and low-speed also from the universal keyboard), convert to Hollerith code, and punch cards
3. To accept data in ASC II code from the CCU and universal keyboard (and low-speed also in ITA #2 from the tape reader), convert data to Hollerith code, and punch cards
4. To effect the input of data from operator keyboards and conversion of such data to ASC II code

11-39. What is the function of the high-speed and low-speed paper punches?
1. To serve as on-line output devices, and for off-line key punch operations in conjunction with the universal keyboard
2. To serve as on-line input devices, receiving incoming messages and relaying them into the CCU as the work-load permits
3. To serve as off-line auxiliary punches in conjunction with the universal keyboard only
4. To serve as primary "mainstream" on-line devices, both input and output, relaying information into and out of the CCU

11-40. The paper tape printer interpreter prints directly on the paper tape. What is the relationship, so far as dependency is concerned, of the operation of the interpreter and the paper punch?
1. The interpreter may be turned off or it may interpret each character at a set interval after punching (to allow for tape transfer between machines) only
2. The interpreter may be turned off, it may interpret each character at a set interval after punching, and it may continue to interpret if the punch is idle and is placed in the "INT ON" position
3. The interpreter may be turned off or it may operate completely independently of the punch so long as the punch is off-line or idle only
4. The operation of the interpreter is completely independent of that of the punch

---

Learning Objective: Identify the types and formats of messages AUTODIN will accept.

11-41. What types of messages will the AUTODIN network accept?
1. Single call only
2. Single call and multiple call only
3. Single call and general only
4. Single call, multiple call, and general

11-42. What formats of messages will the AUTODIN network accept?
1. Plaindress only
2. Plaindress and abbreviated plaindress only
3. Plaindress, abbreviated plaindress, and data pattern only
4. Plaindress, abbreviated plaindress, codress, and data pattern

---

Learning Objective: Identify character positions in the routing indicator.

11-43. How many letters must a routing indicator have?
1. From four to seven
2. From five to seven only
3. Six or seven only
4. Seven only

11-44. What does an "R" in the first position mean?
1. A routine message follows
2. The routing indicator is part of the worldwide tape relay system
3. The message to follow is in the "restricted" category
4. It designates the nation or international alliance of destination

11-45. What does a "U" in the second position mean?
1. An unclassified message follows
2. The groups in the message are uncounted
3. It designated the nation or international alliance of destination
4. It designates the particular geographical area of destination

11-46. What does a "C" in the third position mean?

1. A Confidential message follows
2. It designates the nation or international alliance of destination
3. It designates the particular geo graphical area of the station or substation of destination
4. The routing indicator is part of the common or worldwide tape relay system

11-47. What do letters appearing in positions four through seven designate?

1. Classification and precedence of message, and whether or not answer is required
2. Relay and tributary stations within the network to which the message will be passed
3. Relay and stations through which the message has passed, as each adds his designator as he relays the message
4. Whether transmission is by worldwide or local net, country of destination, particular geographical area of destination, and whether message will go direct to terminal of destination or will be relayed

11-48. In order to ensure that the first character of the message is accepted and transmitted, what is the minimum content of the leader of (a) five-level baudot code and (b) eight-level baudot code?

1. (a) Five blanks and five letter functions, (b) eight nulls and eight delete functions
2. (a) Six blanks and four letter functions, (b) six nulls and four delete functions
3. (a) Six blanks and six letter functions, (b) six nulls and six delete functions
4. (a) Six blanks and six letter functions, (b) six nulls and eight delete functions

11-49. Which of the following correctly gives the significance of "Y" in position 1 (precedence)?

1. This indicates that six or more messages have been sequenced for transmission in descending order of precedence
2. This is an indicator of personal traffic, which is processed on a "time available" basis only
3. This is an indicator of a service message which relates to previous traffic and must be handled without delay
4. This indicates that the message has FLASH preemption capability and is designated Emergency Command precedence

11-50. To what do positions 2 and 3, respectively, relate?

1. The output device preferred by the addressee; the language used in the message
2. The language used in the message; the output device preferred by the addressee
3. The language used in the message; the classification
4. The classification; the output device preferred by the addressee

11-51. Which of the following conditions does a "T" in position 4 indicate?

1. The classification of the message is Top Secret
2. The output device preferred by the addressee is the teletype
3. This message is being processed on a worldwide net system (tape)
4. The media format being used is the five-level baudot code

11-52. Positions 5 through 8 contain four letters or three letters and a number to indicate message content and provide identification for communications handling. What publication contains a complete listing of these codes?

1. JANAP 119
2. JANAP 128
3. ACP 122
4. NWP 4

11-53. What does position 9 contain?

1. A space if the message is addressed to a single addressee; an "M" if it is for multiple addressees
2. A space
3. A "T" if the message is in five-level baudot code; an "A" if it is in eight-level baudot code
4. An "R" if the station's involvement is for relay action; a "D" if the message is to go direct

11-54. After the routing indicator in positions 10 through 16, the station serial number appears in positions 17 through 20. What are two specific purposes served by this number?

1. To provide a means for checking for straggler messages and to identify the subject of the message
2. To identify the subject of the message, and, by means of a code, to serve as a crosscheck of the security classification
3. To assist in providing positive identification, and, by means of a code, to serve as a crosscheck of the security classification
4. To assist in providing positive identification and to provide a means for checking for straggler messages

11-55. If the message was received by the originator for transmission by the communications center on 5 January 1978, what should go in positions 21 through 24?
1. 8005
2. 8105
3. (SPACE)005
4. (SPACE)1(SPACE)5

11-56. What goes in positions 25 through 28?
1. The time of transmission (GMT)
2. The time of receipt from the originator by the communications center (GMT)
3. The time of transmission (local time)
4. The time of receipt from the originator by the communications center (local time)

11-57. If the classification of the message is Confidential and the actual time of transmission is 1015Z, what would go in positions 29 through 33?
1. C1015
2. 1015C
3. -CCCC
4. -CCC-

11-58. What goes in positions 34 and 35?
1. Two hyphens
2. Two blanks
3. Two spaces
4. Two periods

11-59. What is the maximum number of routing indicators that can be listed in one transmission in positions 36 through 42?
1. 200
2. 300
3. 400
4. 500

11-60. What character goes in the position immediately following the last addressee's routing indicator, and by what term is it correctly called?
1. Hyphen; end of heading signal
2. Period; end of heading signal
3. Period; end of routing signal
4. Hyphen; end of routing signal

11-61. What is the correct end of message (EOM) procedure for (a) five-level baudot code, and (b) eight-level baudot code?
1. (a) 2CR, 8LF, 4Ns, 12LTRS; (b) 2CR, 8LF, 4Ns, 12LTRS
2. (a) 2CR, 8LF, 4Ns, 12LTRS; (b) 12DEL
3. (a) 12DEL; (b) 2CR, 8LF, 4Ns, 12LTRS
4. (a) 12DEL; (b) 12DEL

11-62. As RM3 Schmeer is preparing the message header, he accidentally strikes the LETTERS function twice in succession. Which, if any, of the following occurrences will happen as a result of the extra LETTER function?
1. The teletype will switch back to figures at the second LETTER function
2. The teletype will jam
3. The message will be rejected by the ASC
4. None of the above

11-63. If, in transmitting a message, RM3 Johnson makes an error in the EOM validation in format line 15, realizes it immediately, completely blocks out the error, inserts the correct information, and completes the message with no further errors, which of the following actions will occur?
1. The message will process successfully through the ASC
2. The message will be rejected by the ASC
3. The part of the tape containing the blocked out error will jam the receiving machine at the ASC
4. The ASC will relay the first part of the message, but the blocked out portion of the tape will cause it to skip to the next message

---

Learning Objective: State some general rules regarding TTY operation and format.

11-64. When a TTY tape is cut for transmission, using ASC II code, what functions, as a minimum, should precede the message header?
1. Six nulls and six deletes
2. Six blanks and six letters
3. Six letters and six figures
4. Six nulls and six blanks

11-65. If a message which contains the colon symbol (:) must be refiled commercially, which of the following actions should the operator take prior to transmission?
1. He should convert the ":" to "COLON"
2. He should convert the ":" to "CLN"
3. He should replace the ":" with ".."
4. He should replace the ":" with a blank

11-66. RM3 Rolfe receives for transmission a message with a dual precedence: FLASH for the action addressee, and PRIORITY for the information addressee. In which of the following ways should he transmit this message?

1. He should make two separate transmissions: one to the action addressee, indicating "FLASH" in line 2; and one to the info addressee, indicating "PRIORITY" only in line 5
2. He should make two separate transmissions: one to the action addressee, indicating "FLASH" in line 2; and one to the info addressee, indicating both precedences in line 5
3. He should make only one transmission, and indicate "FLASH" in line 2 and both precedences in line 5
4. He should make only one transmission, and indicate "FLASH" in line 2 and "PRIORITY" only in line 5

11-67. In a long off-line encrypted message being transmitted in sections, what should the group count in format line 10 of a section include?

1. The number of groups in the complete message, the cryptopart identification, the page identification, and the transmission section identification
2. The number of groups in the complete message, the cryptopart identification, and the page identification only
3. The number of groups in the text section being transmitted and the cryptopart identification
4. The number of groups in the text section being transmitted only

---

Learning Objective: Explain and interpret the group of characters and operations that prefix the message header in modes II, IV, and V.

VZCZCJTA(FIGS)123(LTRS)(2CR)(1LF)

Figure 11A

- Refer to figure 11A, a transmission preceding a message header, in answering questions 11-68 and 11-69.

11-68. What is the correct term for this group of characters and operations?

1. Transmission identification (TI)
2. Header prefix (HP)
3. Notification of transmission (NT)
4. Message identifier (MI)

11-69. What are the station/channel designator letters?

1. VZC
2. ZCZC
3. CJT
4. JTA

To answer questions 11-70 through 11-73, select from column B the operating and classification characters that match the usage descriptions given in column A.

	A. Usage Descriptions	B. Characters
11-70.	Used for unclassified EFTO messages	1. ZNR UUUUU
		2. ZNY AAAAA
11-71.	Used for Special Category (SPECAT) messages	3. ZNY CCCCC
		4. ZNY EEEEE
11-72.	Used for off-line encrypted messages and classified messages that are transmitted in the clear	
11-73.	Used for Confidential messages	

A. Send a message to the originating station saying "Your (DTG) not for us. Retransmit."

B. Obtain the correct routing indicator.

C. Label the message "SUSDUPE" to indicate it is a suspected duplicate.

D. Replace the header, and retransmit the message to the correct routing indicator.

E. Attach a service message to the message informing the recipient that the message had been missent to (identification of tributary station).

F. Send a service message to the originating station advising him of the reroute action and correct routing indicator.

List 11A

- Use list 11A in answering question 11-74.

11-74. Which of the preceding actions should be taken by a tributary station which has received a misrouted message? (Assume that the correct routing indicator is obtainable.)
1. A
2. B, C, D, E
3. B, D, F only
4. B, D, E, F

11-75. What is the difference, if any, between a misrouted and a missent message?
1. A misrouted message goes through a relay station; a missent one does not
2. A misrouted message is transmitted on line; a missent one, off line
3. A misrouted message contains an incorrect routing instruction; a missent message, a correct one
4. None; these are two interchangeable terms

Assignment 12

Automated Systems (Continued)

Textbook Assignment: Pages 305 - 322

Learning Objective: Describe actions to be taken relative to suspected duplications (SUSDUPEs).

12-1. If an operator receives a message marked "SUSDUPE" after he has received and delivered the original (identical) message, what should he do with the duplicate?
1. He should file it
2. He should destroy it
3. He should deliver it to the addressee only
4. He should deliver it to the addressee with an attached brief message of explanation

A. Check the records to determine whether the message was duplicated.

B. If the message was duplicated, check in-station procedures regarding message handling, and train personnel as necessary.

C. If the message was duplicated, check the equipment if equipment malfunction is suspected.

D. Advise the connected ASC via service message if only one transmission can be accounted for.

E. Advise the connected ASC via service message if the transmission was duplicated.

F. Report to the connected ASC the measures taken to attempt to eliminate future duplications, if the message was duplicated.

List 12A.

- Use list 12A in answering question 12-2.

12-2. Which of the preceding actions should the originating station take upon receipt of a service message advising of or inquiring about a suspected duplicate?
1. A through C only
2. A through D only
3. A through E only
4. A through F

Learning Objective: Describe the data pattern message and related characteristics and operating procedures.

12-3. How many characters are normally contained in each record block of data pattern messages?
1. 40
2. 60
3. 75
4. 80

12-4. What is the maximum number of cards (NOT counting cards used as pilots) that may be included in one transmission via message switching facilities?
1. 250
2. 300
3. 400
4. 500

12-5. For what is the Data Message Form (DD Form 1392) normally used?
1. To aid the originator in drafting a message text
2. To aid the originator in preparing the message header
3. To keep a running record, by station serial number, of incoming and outgoing messages
4. To keep a running record, by DTG, of incoming and outgoing messages

12-6. By whom and for what purpose is the Message Correction Notice (DD Form 1503) normally used?
1. By the communication facility to notify the originator of message discrepancies
2. By the recipient to notify the communication facility of message discrepancies
3. By the originating station to notify the drafter of discrepancies
4. By the ASC supervisor to notify the operators of discrepancies

● Use the following information in answering question 12-7: CC = card to card, CT = card to tape, CA = card to ASC II, TC = tape to card, AC = ASC II to card.

12-7. In data message format, (a) what is the most common language and media format (LMF), and (b) what other LMFs are available for use?
1. (a) CC; (b) CA, TC, AC only
2. (a) CC; (b) CA, AC, TC, CT
3. (a) CA; (b) CC, CT, TC
4. (a) CA; (b) CC, TC, AC

12-8. Which of the following may be prepared by automatic message originators?
1. The communication header only
2. The header and text with partial text header information only
3. The header and text with complete text header information only
4. The header, text (with complete text header information), and EOT formats (with all necessary information)

12-9. Other than relaying the message, what action(s), if any, should communications facility personnel take if a message arrives at their facility more than thirty minutes later than the time in format line 2?
1. Preparing a service message to trail the message and informing the recipient of the time of receipt and processing by the center
2. Correcting the time in format line 2; advising the originator via the Message Correction Notice (DD 1503)
3. Sending a service message to the originator and one to the addressee notifying them of the time of processing
4. None

12-10. In what publication can the designators for the language and media format be found?
1. NTP 3
2. NWP 4
3. ACP 122
4. JANAP 128

12-11. How many characters must the routing indicator field contain?
1. Five
2. Six
3. Seven
4. Eight

12-12. What SSN would the next message after 9999 bear?
1. 0000
2. 0001
3. 9001
4. 10000

12-13. If a message was drafted by the originator at 1530 local time (0930Z) and was received by the center at 1536 local time (0936Z), what should be placed in positions 25 through 28 (time filed)?
1. 0930
2. 0936
3. 1530
4. 1536

12-14. What characters should go in positions 39 and 40, designated for the start of routing indicator?
1. SR
2. AA
3. --
4. //

12-15. (a) What is the maximum number of addressee routing indicators that can be listed without requiring a separate transmission, and (b) of what does the end of routing signal consist?
1. (a) 300, (b) a period
2. (a) 300, (b) a hyphen
3. (a) 500, (b) a period
4. (a) 500, (b) a hyphen

523

12-16. The first part of the End of Transmission (EOT) consists of a repeat of positions 1 through 38. Of what does the remainder consist for (a) a single-record transmission and (b) a multiple-record transmission?
1. (a) Ns in positions 77-80, (b) N in position 80 only
2. (a) Ns in positions 77-80, (b) Ns in positions 77-80
3. (a) N in position 80 only, (b) Ns in positions 77-80
4. (a) N in position 80 only, (b) N in position 80 only

12-17. Unless an exception has been granted, what is the minimum time for which (a) data pattern messages must be retained intact, and (b) the header must be retained?
1. (a) 7 days, (b) 30 days
2. (a) 7 days, (b) 60 days
3. (a) 10 days, (b) 60 days
4. (a) 10 days, (b) 30 days

The following situation applies to questions 12-18 through 12-20: A center, using message batching or commingling, is preparing to combine and send ten messages as one transmission. To answer these questions, select from column B the number that tells how many, if any, of the items shown in column A must be included in the transmission.

	A. Items for Possible Inclusion	B. Number Required
12-18.	Header card	1. One
12-19.	EOT card	2. Ten
12-20.	General purpose content indicator code	3. None

12-21. A certain terminal does NOT receive printed journal entries. Which of the following selections lists two actions communications personnel must perform after receipt of data pattern traffic?
1. Verifying the message record count and recording the SSNs in the log
2. Duplicating the header for record purposes and recording the SSNs in the log
3. Endorsing the header card to show the time of receipt and duplicating the header for record purposes
4. Endorsing the header card to show the time of receipt and verifying the message record count

---

Learning Objective: Describe Magnetic Tape Terminal Station (MTTS) operation and format.

12-22. What is the basic mode of Magnetic Tape Terminal Station (MTTS) operation with other AUTODIN tributary stations?
1. Simplex only
2. Either simplex or duplex
3. Either simplex or store and forward
4. Either duplex or store and forward

12-23. What is the deciding factor in determining the sequence of transmission of several tape reels received for transmission?
1. The majority message precedence level
2. The majority message classification level
3. The reel rating according to a formula based on both precedence and classification
4. The sequence in which the reels arrived

12-24. A printout is made of the headers and EOTs of messages on each reel. Who is responsible for furnishing this printout?
1. The message originator
2. A person assigned to the MTTS, whose primary duties are limited to receipting for reels and making message header and EOT printouts
3. In each case, the operator who transmits that reel
4. The senior E-6 or below in the MTTS

12-25. Which of the following statements reflects the policy on splicing magnetic tapes used for traffic?
1. The splicing of such tapes is authorized only if the angle of cut is diagonal to the side of the tape and precision work is done
2. The splicing of such tape is authorized only if the tape is cut at right angles to the edge of the tape and precision work is done
3. The splicing may be done at any angle so long as precision work is done
4. The tape may not be spliced

12-26. What is the language of transmission from an MTTS?
1. Hollerith
2. ASC II
3. ITA #2

12-27. An operator has records of 19 and 1152 characters, respectively, to send by AUTODIN, and asks if he may send them without checking the addressee's receiving capabilities. He should have known that the addressee's receiving capabilities must be checked if the record contains (a) less than, and (b) more than what number of characters?
1. (a) 18, (b) 1000
2. (a) 18, (b) 1200
3. (a) 20, (b) 1000
4. (a) 20, (b) 1200

12-28. Who is responsible for the preparation of magnetic tape messages, formats, routing, contents, and sequence on tape?
1. The supervisor of the MTTS
2. A person specifically assigned "tape control" duties by the MTTS supervisor
3. The person who accepts and signs for the reel
4. The originator

12-29. What is the minimum number of days for which (a) originated tape reels, and (b) header and EOT printouts should be retained?
1. (a) 10, (b) 30
2. (a) 20, (b) 10
3. (a) 30, (b) 20
4. (a) 30, (b) 30

12-30. What is the name of the MTTS log which reflects the status and lists outages, repairs, etc. of equipment and circuits?
1. The Status and Maintenance Log
2. The Daily Operations Log
3. The Master Station Log
4. The Equipment/Circuit Log

12-31. What should be recorded in the Reel Delivery Log?
1. Reel number, number of messages contained, highest classification, and time delivered to the transmitting operator or the addressee
2. Reel number, highest classification, highest precedence, and time delivered to the transmitting operator or the addressee
3. Reel number, from whom received, highest classification, and time delivered to the transmitting operator or the addressee
4. Reel number and time delivered to the transmitting operator or the addressee only

---

Learning Objective: Describe procedures following the attempted transmission of classified traffic over a circuit NOT authorized to carry it or to an addressee NOT authorized to receive it, and identify the location of security regulations for AUTODIN.

12-32. What action follows the sending of a classified message to an ASC over a circuit NOT authorized for use with that degree of classification?
1. The message is accepted, but the bell rings an alert, and an automatically generated service message is sent to the originator, advising of the possible security compromise
2. The message is rejected, the bell rings an alert, and an automatically generated service message is sent to the originator, advising of the possible security compromise
3. The message is rejected, and an automatically generated service message is sent to the originator, advising of the possible security compromise only
4. The message is rejected only

12-33. Which of the following sets of actions is descriptive of those that occur when a message is routed through the ASC to a destination which does NOT have the necessary clearance to receive it, if it is (a) a single-address message, and (b) a multiple-address message?

1. (a) The message is accepted and filed by ASC, and ASC sends a service to the originator;
   (b) the message is accepted and forwarded to the authorized recipients, and ASC sends a service to the originator
2. Both (a) and (b), the message is rejected by ASC; for invalid routing indicators, an automatically generated service advises the originator of the need for retransmission
3. Both (a) and (b), the message is rejected by ASC; alarms will appear at the originating terminal indicating the need for retransmission
4. (a) The message is rejected by ASC, alarms will appear at the originating terminal indicating the need for retransmission;
   (b) the message is accepted and forwarded to any authorized recipients; for invalid routing indicators, an automatically generated service advises the originator of the need for retransmission

12-34. In what publication can complete security precautions and operating rules for AUTODIN be found?

1. JANAP 128
2. JANAP 137
3. NTP 3
4. NTP 8

Learning Objective: Describe the geographical coverage of AUTOVON and define some of the terms associated with that system.

12-35. The Defense Communications System Automatic Voice Network (AUTOVON) includes activities at which of the following locations?

1. Continental United States (CONUS) only
2. Overseas only
3. CONUS and five overseas locations only
4. CONUS and many overseas locations

12-36. What is the difference between an AUTOVON subscriber and an AUTOVON user?

1. An AUTOVON subscriber gains access to AUTOVON by dialing an access code; an AUTOVON user gains access by placing a call through a PBX
2. An AUTOVON subscriber has direct access to AUTOVON; an AUTOVON user has indirect access
3. An AUTOVON user has direct access to AUTOVON; an AUTOVON subscriber has indirect access
4. An AUTOVON subscriber is an activity which is served by AUTOVON; an AUTOVON user is the individual who actually makes or receives an AUTOVON call

12-37. What is the term that means the seizing of telecommunications before or in preference to other subscribers' calls, even those already in progress?

1. Prioritization
2. Preemption
3. Precedence
4. Preference

12-38. What is the difference in the procedure for joining in on a pre-set conference and a random conference?

1. For pre-set, users dial a prescribed number; for random, the AUTOVON operator assists
2. For pre-set, users request connection through an AUTOVON operator; for random, users dial a prescribed number
3. For pre-set, users have scheduled the AUTOVON call previously by message; for random, users call other users to join them as the need arises
4. For pre-set, users have had the prescribed telephone number on file for at least 30 days; for random, a user must call for a number and then relay it to the others who will participate in the conference

---

Learning Objective: Differentiate among the classes of telephone service available on board military installations.

To answer questions 12-39 through 12-43, select from column B the class of telephone that is associated with the characteristic shown in column A.

A. Characteristics

12-39. Service available for transaction of official business on DOD or military installations; NO access to commercial telephone company trunks

12-40. Service installed on military installations for official business; restricted to special classes of use, such as fire alarm, crash alarm, or security

12-41. Service available for transaction of official business on DOD or military installations; requires access to commercial telephone company trunks

12-42. Service installed in or near a military PBX or CENTREX system; authorized for personal or unofficial business; requires access to commercial telephone company trunks

12-43. Users of this class may initiate outgoing official business phone calls in the AUTOVON network

B. Classes

1. Class A
2. Class B
3. Class C
4. Class D

Learning Objective: Differentiate among the types of calls assigned each precedence.

To answer questions 12-44 through 12-47, select from column B the precedence assignment that matches the circumstance or type of information described in column A.

A. Information

12-44. Calls pertaining to conduct of diplomatic negotiations critical toward limiting or stopping hostilities

12-45. Calls requiring rapid transmission, but NOT preferential handling

12-46. Calls requiring expeditious action by calling party and/or calls which furnish information essential for the conduct of government operations

12-47. Calls concerning intelligence reports concerned with national security

B. Precedences

1. FLASH
2. IMMEDIATE
3. PRIORITY
4. ROUTINE

Learning Objective: Differentiate among the types of service provided for AUTOVON users.

To answer questions 12-48 through 12-51, select from column B the type of service associated with the characteristics shown in column A.

A. Characteristics

12-48. When the telephone is lifted off its cradle, it is immediately connected to a predesignated telephone instrument at a distant installation

12-49. By dialing direct or by enlisting the services of a local operator, the subscriber may contact other subscribers, worldwide, for day-to-day low-precedence communication. When push-button four-wire telephone sets are used, any precedence calls may be employed

12-50. This type of service provides access to specially conditioned trunks which provide the transmission capability sometimes required by data and facsimile stations

12-51. Subscribers utilizing this service may have the privacy afforded by a denial of access to and from other nets

B. Types of Service

1. General Purpose
2. Special
3. Off-hook
4. Special Grade

Learning Objective: State security precautions relative to AUTOVON, and tell where to find instructions regarding the use of AUTOVON.

Questions 12-52 and 12-53, dealing with general information for AUTOVON users, are to be judged True or False.

12-52. The AUTOVON is a secure line, but users must be careful to make sure NO one is within earshot in the office when classified subjects are to be discussed.

12-53. An AUTOVON directory, containing general instructions for placing calls on AUTOVON and for reporting AUTOVON trouble, is published periodically and distributed to subscribers connected to respective AUTOVON switches.

Learning Objective: Define some basic terms relative to Automatic Secure Voice Communications (AUTOSEVOCOM).

12-54. As it relates to naval communications, what is the meaning of the term "approved circuit"?
1. A foreign harbor circuit for which permission for U.S. Navy use has been requested and granted
2. A circuit which has been authorized for passing of encoded material of specific security classifications
3. A circuit which has been authorized for plain language transmissions of specific security classifications
4. Any circuit which conforms to safety standards and is available for Navy use

12-55. What does the term "cross talk" mean?
1. The garbled sound that results from more than one operator speaking on the same circuit at the same time
2. The sound heard in a receiver resulting from telephone currents in another channel
3. Intentional voice interference (or voice jamming) on a circuit
4. Communication by voice from one mobile naval unit to another; i.e., ship-to-ship

Learning Objective: State the location of instructions and describe some of the procedures concerning the operation of AUTOSEVOCOM.

12-56. Where should you look to find specific instructions concerning correct placement of calls on the AUTOSEVOCOM network?
1. In the local AUTOSEVOCOM directory
2. In the local AUTOVON directory
3. In NTP 9
4. In ACP 125

12-57. Which of the following statements regarding precedents used via the AUTOSEVOCOM network is correct?
1. Since so many users have routinely assigned higher precedences than required, it is now recommended that a precedence one level higher than that prescribed by existing circumstances be assigned, as a standard rule-of-thumb
2. An IMMEDIATE call will normally preempt an IMMEDIATE call in progress
3. A PRIORITY call will normally preempt a PRIORITY call in progress
4. Precedences used on the AUTOSEVOCOM network are as prescribed by the Joint Uniform Telephone Communications Precedence System

12-58. What is the minimum classification level at which the call originator must authenticate, ensuring that the called party is cleared for the information to be discussed?
1. Confidential
2. Secret
3. Top Secret

12-59. If an AUTOSEVOCOM user hears cross talk on his call, what should he do in addition to any required reporting of the inadvertent disclosure of classified information?
1. He should employ tracer techniques in an attempt to ascertain the identity of the other party
2. He should immediately report the incident, in detail, to the security officer
3. He should hang up and call again
4. He should report the occurrence, in detail, to the switch operator serving the termination

Learning Objective: Identify, define terms associated with, and describe purposes, procedures, and benefits connected with MPDS, LDMX, NAVCOMPARS, and IXS.

12-60. For what is MPDS an acronym, and what is it?
1. The Message Processing and Distribution System, a shipboard message-switching system which processes, stores, logs, and routes traffic
2. The Multi-Purpose Digital System, a step forward in the processing of traffic by increased interface with digital computers
3. The Multi-Purpose Data System, an innovation in overall handling of data, including message traffic, by more fully automatic means
4. The Multiplex/Phone/Duplex System, a fascinating achievement in shipboard communications, linking various communications systems together and making the entire macrosystem available for rapid processing of traffic

12-61. Which of the following actions does LDMX NOT perform on outgoing messages?
1. Validating the message identifiers
2. Searching system files to assign correct routing indicators
3. Counting, verifying, and printing group count
4. Arranging messages in precedence order for transmission

12-62. If a major component of the LDMX becomes inoperable, to what extent, if at all, can the system continue to operate?
1. The system can still operate in the semiautomatic or manual mode
2. The system can still operate in the manual, but seldom in the semiautomatic, mode
3. The system can still operate in the manual, but NOT the semi-automatic, mode
4. The system can not operate until the faulty component is again operable

12-63. In the LDMX system, the detection of a mismatch in a security field of a Secret message would result in which of the following occurrences?
1. The display of the message to an inrouter or outrouter for review and action
2. The sounding of the discrepancy alarm
3. The flashing of the red mismatch light
4. All of the above

12-64. The LDMX system is rapid. In which of the following ways can it also be correctly described?
1. It is reliable and secure, but lacks flexibility
2. It is reliable, secure, and flexible, but it requires significantly more personnel and equipment as the traffic load increases
3. It is secure and flexible, but, because of frequent maintenance requirements, is rather unreliable
4. It is reliable, secure, and flexible, and it will handle increases in traffic without increases in manpower and equipment

12-65. What is the primary purpose of NAVCOMPARS?
1. To maintain a running inventory and maintenance record of all communications equipment
2. To serve the fleet by providing automated communications processing and routing
3. To provide automated communications processing and routing among various shore-based units
4. To link subscribers together for the exchange of information by way of a satellite path

12-66. What is the maximum number of continuous lines of message headings and text a fleet unit operating directly with a NAVCOMSTA equipped with NAVCOMPARS may transmit without dividing the message into two sections?
1. 100
2. 100 text + standard heading
3. 350
4. 550

12-67. What is the IXS?
1. A newly-developed intercommunications system
2. An up-to-date system used for troubleshooting communications equipment
3. A system by which subscribers may exchange information via a satellite path
4. A system which simultaneously transmits and receives messages over AUTODIN to provide rapid, accurate, reliable processing

12-68. (a) On what type of unit is the SSIXS intended for installation, and (b) what is the relationship of the SSIXS with other communications equipment already installed?
1. (a) Submarine, (b) the SSIXS completely replaces the existing communications system
2. (a) Submarine, (b) the SSIXS complements the existing communications system
3. (a) Aircraft, (b) the SSIXS completely replaces the existing communications system
4. (a) Aircraft, (b) the SSIXS complements the existing communications system

12-69. CUDIX is the automated information subsystem that was developed especially for the purpose of enabling rapid exchange of information between/among
1. the aircraft squadron commander and each member of his squadron
2. ships at sea and aircraft
3. fleet mobile units and activities ashore
4. activities ashore

Assignment 13

Fleet Communications

Textbook Assignment; Pages 323 - 338

Learning Objective: Define the control and organization of the fleet multichannel broadcast (MULCAST) system.

13-1. Which of the following actions is taken to help assure that each ship can receive all transmissions made by the Fleet Multichannel Broadcast (MULCAST) System, regardless of ship location?

1. Immediately after each message is broadcast, it is repeated
2. The HF broadcast is transmitted on several frequencies at the same time
3. Message traffic is transmitted from five different Naval Communication Area Transmitting Stations (NAVCATS) within each ocean area
4. Official traffic is routed through a special amplifier unit, called a Super Power Pack (SPP)

13-2. What are the locations of the Naval Communications Area Master Stations acting as (a) NAVCAMSLANT and (b) NAVCAMSMED, respectively?

1. (a) Norfolk, (b) Naples
2. (a) Lajes, (b) Naples
3. (a) Lajes, (b) Gaeta
4. (a) Norfolk, (b) Gaeta

13-3. What are the locations of the Naval Communications Area Master Stations acting as (a) NAVCAMSEASTPAC and (b) NAVCAMSWESTPAC, respectively?

1. (a) Midway, (b) Cubi Point/Subic Point
2. (a) Honolulu, (b) Cubi Point/Subic Point
3. (a) Midway, (b) Guam
4. (a) Honolulu, (b) Guam

To answer questions 13-4 through 13-7, select from column B the terms that match the definitions in column A.

	A. Definitions	B. Terms
13-4.	The activity responsible for placing the message traffic directly into the broadcast	1. Broadcast Control Authority (BCA) 2. Broadcast Control Station (BCS)
13-5.	The controller of a specific broadcast	3. Broadcast Keying Station (BKS)
13-6.	The activity that engineers the broadcast and delivers the keying to the transmitting stations	4. Broadcast Radiation Station (BRS)

13-7. A station responsible for radiating a signal from a broadcast supplied by the activity that engineers the broadcast and delivers the keying

---

Learning Objective: Explain the significance of the broadcast designator, tell where to find a list of broadcast designators, and identify the components of the fleet multichannel broadcast system equipment.

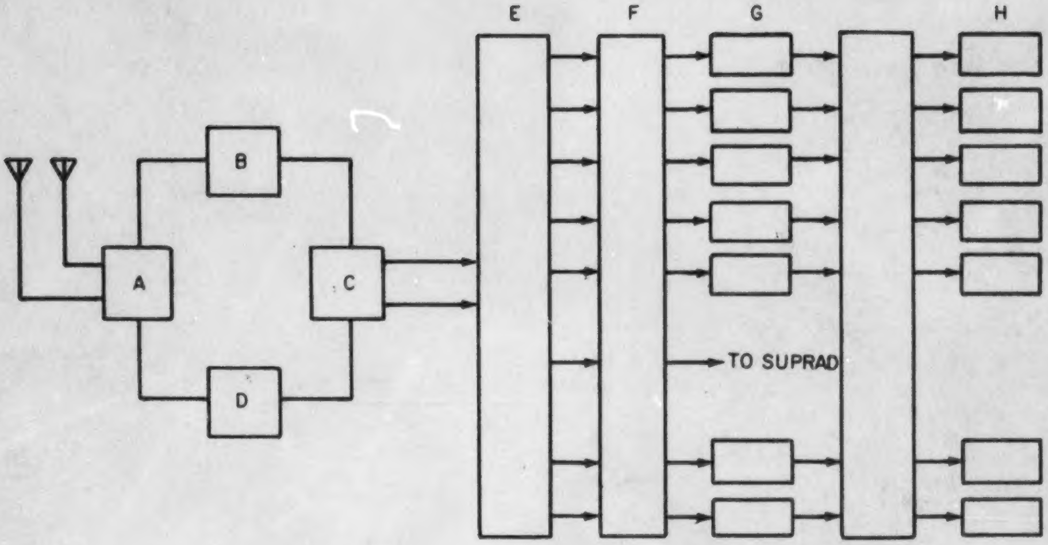


Figure 13A.—Fleet multichannel broadcast ("N" system).

- Refer to figure 13A in answering questions 13-8 through 13-11.

To answer questions 13-8 through 13-11, select from column B the component represented by the letter shown in column A.

	A. Identifying Letters	B. Components
13-8.	A	1. Antenna coupler
13-9.	B	2. Audio transfer switchboard
13-10.	C	3. Filter
13-11.	D	4. Receiver

To answer questions 13-12 through 13-15, select from column B the equipment represented by the letter shown in column A.

	A. Identifying Letters	B. Equipment
13-12.	E	1. Black DC patch panel
13-13.	F	2. Crypto equipment
13-14.	G	3. Multiplex equipment
13-15.	H	4. Teletype machines

13-16. What do the characters in the broadcast designator signify?
1. The first indicates the type of broadcast, and the second, the naval communications area of origin
2. The first indicates the type of broadcast, the second and third consist of the identification number assigned, and the fourth identifies the naval communications area of origin
3. The first identifies the naval communications area of origin, subsequent characters indicate the type of broadcast
4. The first identifies the naval communications area of origin; the second, the type of broadcast; and the third and fourth, the identification number

13-17. In what publication can a complete list of broadcast designators be found?
1. NTP 3
2. NTP 4
3. ACP 121
4. ACP 122

13-18. Into how many channels is the MULCAST divided?
1. 12
2. 14
3. 16
4. 18

Learning Objective: Define various MULCAST operating procedures.

13-19. While an operator on a ship was copying routine traffic, an emergency event occurred which caused him to miss a broadcast number. How should he obtain it?
1. By sending "BREAK" to the transmitting station, and, when his "BREAK" is acknowledged, asking for a repeat
2. By sending a service message to the broadcast control station, requesting a repeat
3. By copying it from his primary channel one hour later
4. By copying it from his secondary channel one hour later

13-20. Where is the broadcast alignment procedure outlined?
1. NTP 3
2. NTP 4
3. JANAP 128
4. ACP 122

13-21. When does the MULCAST require restart?
1. At the beginning of each crypto day only
2. At the beginning of each crypto day and any time synchronization is lost only
3. At the beginning of each crypto day and after each time message serial number 999 is received
4. At the beginning of each crypto day, any time synchronization is lost, and at the change of each watch

13-22. What functions does the TSEC/KWR-37 crypto device provide?
1. Decryption of message traffic and timing for the TSEC/KG-14 only
2. Encryption of message traffic and timing for the TSEC/KG-14 only
3. Decryption and encryption of message traffic and timing for the TSEC/KG-14
4. Decryption and encryption of message traffic only

13-23. If a spare TSEC/KWR-37 is available, approximately how many minutes before the new crypto day begins should (a) the new day's key card be inserted, and (b) the new TSEC/KWR-37 be patched in?
1. (a) 15, (b) 1
2. (a) 15, (b) 5
3. (a) 45, (b) 1
4. (a) 45, (b) 5

13-24. In what publication are the operating instructions for the TSEC/KWR-37 found?
1. KAO-34 (series)
2. H.O. 117
3. JANAP 119
4. JANAP 128

13-25. If a ship is transitting the Atlantic and is going to make a routine broadcast shift, at what time should the operator (a) shift from one broadcast to another and (b) send the broadcast shift message?
1. (a) 0800Z, (b) in time to reach the destination by 0001Z
2. (a) 0800Z, (b) in time to reach the destination by 1600Z, preceding day
3. (a) 0001Z, (b) in time to reach the destination by 1201Z, preceding day
4. (a) 0001Z, (b) in time to reach the destination by 1600Z, preceding day

13-26. If an emergency broadcast shift occurs, what precedence should the message of notification have?
1. ROUTINE only
2. ROUTINE or PRIORITY
3. PRIORITY or IMMEDIATE
4. IMMEDIATE or FLASH

13-27. What is the minimum number of days for which broadcast copies, carbons, and tapes must be retained?
1. 10
2. 15
3. 20
4. 30

13-28. If Top Secret messages which were received but NOT addressed to an afloat command are destroyed, (a) how many witnessing officials must initial the check-off sheet next to the appropriate broadcast serial numbers, and (b) how long must the check-off list be retained?
1. (a) 1, (b) 30 days
2. (a) 2, (b) 10 days
3. (a) 3, (b) 10 days
4. (a) 3, (b) 2 years

13-29. If a Radioman has missed broadcast numbers applicable to his ship and has exhausted all other means of obtaining them, without success, he should send a Broadcast Screen Request. Who should be (a) the action addressee, (b) the information addressee, and (c) a second information addressee if more than 25 broadcast numbers were missed?
1. (a) BKS, (b) BCS, (c) BCA
2. (a) BKS, (b) the appropriate NAVCAMS, (c) his numbered fleet commander
3. (a) BCS, (b) BCA, (c) the appropriate NAVCAMS
4. (a) BCS, (b) the appropriate NAVCAMS, (c) his numbered fleet commander

13-30. At regular intervals, a message summary heading recap is sent on each first-run broadcast channel. How often does this occur?
1. Once an hour
2. Once every four hours
3. Once every six hours
4. Once a day

A. To list the number of messages received/transmitted via the broadcast

B. To list the precedence of each message

C. To list the classification of each message

D. To list the date-time group (DTG) of each message

E. To serve as the record of destruction for classified messages

List 13A

Use list 13A in answering question 13-31.

13-31. Which of the preceding functions does the Broadcast Circuit Number Log and Record of Destruction serve?
1. A through E
2. A, B, C, and E only
3. A, B, and E only
4. A, C, and E only

Learning Objective: Explain how to identify single channel broadcasts, and define procedures applicable to submarine broadcasts.

13-32. Single channel broadcasts are identified as such by the COMMAREA designator followed by
1. SGL or SCB
2. SGL or SPG
3. RTT or SPG
4. RTT or SGL

13-33. Which of the following statements reflects the normal procedure concerning the new cryptographic day in the submarine broadcast system?
1. The cryptographic day for all submarine traffic is 0001Z, and the first transmission is the message with the highest precedence
2. The cryptographic day for all submarine traffic is 0001Z, and the first message is a traffic list
3. The cryptographic start times are staggered, and the first message of the cryptoday is a traffic list
4. The cryptographic day start times are staggered, and the first message of the cryptoday is the message with the highest precedence

13-34. How many times are transmissions repeated on submarine broadcasts?
1. Twice only
2. Two, three, or four times, as required
3. Four, six, or eight times, as required
4. Three, four, six, or twelve times, as required

13-35. What is VERDIN?
1. The most widely used single-channel submarine broadcast system
2. A multichannel submarine broadcast system using minimum shift keying (MSK)
3. A multichannel MERCAST system which transmits traffic 40% faster than the old system
4. A category of weather schedules dealing with potentially dangerous weather

---

Learning Objective: Describe the Composite Fleet/General Broadcast (CMP), and describe related transmission formats and operating procedures.

13-36. Which of the following statements correctly describes a Composite Fleet/General Broadcast (CMP)?
1. It is a CW broadcast system serving U.S. fleet units which are unable to copy a covered broadcast, and also serving Allied ships and other authorized users
2. It is basically a teletype system of communications, sending message traffic and weather and hydrographic messages to U.S. and friendly foreign warships
3. It is a single sideband communication system which handles message traffic and weather and hydrographic messages to and from U.S. and friendly foreign warships
4. It is a broad-coverage, world-wide CW communication system, serving both fleet-based and shore-based units of U.S. and friendly forces

13-37. Which of the following transmissions is in the correct format for a call-up for a fleet schedule?
1. NERK NERK NERK DE NAB NAB NAB FLEET
2. NERK NERK NERK DE NAB NAB NAB K
3. NERK NERK NERK FROM NAB NAB NAB K
4. NERK NERK NERK FROM NAB NAB NAB FLEET

13-38. Which of the following transmissions illustrates the correct format of the complete transmission immediately prior to the first message of a fleet schedule?
1. NERK NERK NERK DE NAB NAB NAB K
2. NERK NERK NERK DE NAB NAB NAB ZBO 04
3. EEEEEEEE NERK NERK NERK DE NAB NAB NAB ZBO 04 AR
4. EEEEEEEE NERK NERK NERK DE NAB NAB NAB ZBO 04

13-39. What does the operating signal ZIA preceding a message mean?
1. There has been at least one other message on this same subject within the past 24 hours
2. This message is sent out of sequence, ahead of those with a lower precedence
3. One or more classified messages follow
4. This is the first section of a multisection message

13-40. After all fleet traffic has been transmitted, a QRU tape should be transmitted in which of the following formats?
1. NERK NERK NERK DE NAB QRU AR
2. NERK NERK NERK DE NAB NAB NAB NR 004 QRU AR
3. EEEEEEEE NERK NERK NERK DE NAB QRU AR
4. EEEEEEEE NERK NERK NERK DE NAB NAB NAB NR 004 QRU AR

13-41. At the beginning of a fleet schedule, if the transmitting station has NO traffic, the operator should send a transmission in which of the following formats?
1. NERK NERK NERK DE NAB QRU AR
2. NERK NERK NERK DE NAB NR 004 QRU AR
3. EEEEEEEE NERK NERK NERK DE NAB QRU AR
4. EEEEEEEE NERK NERK NERK DE NAB NAB NAB NR 004 QRU AR

13-42. In what publication is there detailed information concerning MERCAST systems during peacetime?
1. ACP 122
2. ACP 149
3. H.O. 117
4. KAO 34 (series)

13-43. In what publication are the wartime schedules and frequencies of each Allied MERCAST area?
1. ACP 122
2. ACP 149
3. H.O. 117
4. KAO 34 (series)

13-44. How many minutes before the hydrographic schedule time is the call-up usually made?
1. 3 min
2. 5 min
3. 7 min
4. 10 min

13-45. How should a Radioman find out the schedule and frequencies for the Navy weather schedules?
1. By requesting them from the BKS
2. By requesting them from the BCS
3. By requesting them from the BCA
4. By looking in the COMMAREA Communications Information Bulletins (CIBs)

13-46. If the commanding officer and other competent authority impose NO additional directives, what are the requirements, if any, regarding the copying of the weather schedule by (a) ships with weather units, and (b) ships without weather units?
1. Both (a) and (b), copy the entire Navy broadcast for their areas
2. (a) Copy the entire Navy broadcast for their areas, (b) copy at least the synoptic schedules of the Navy broadcast for their areas
3. (a) Copy at least the synoptic schedules of the Navy broadcast for their area, (b) none
4. Both (a) and (b), none

13-47. In what order are Composite Fleet/General Broadcast schedule messages filed in the communication center?
1. By date-time group
2. By classification
3. By subject
4. Incoming, by station of origin; outgoing, by addressee

13-48. At least how often should entries be made in the radio log?
1. Every five minutes
2. Every ten minutes
3. Every fifteen minutes
4. Every twenty minutes

13-49. When, if ever, must the radio log be signed in ink?
1. When the watch changes, when a net or circuit is closed down, and when any abnormal or unusual circumstance is recorded in the log
2. When the watch changes and when a net or circuit is closed down only
3. When the watch changes only
4. Never. Operator initials or designator letters are used

Learning Objective: State the purpose of the facsimile broadcast, and describe related general operating procedures.

13-50. For what purpose is the facsimile broadcast normally used?
1. To receive illustrated news bulletins
2. To receive weather maps
3. To receive navigational maps
4. To receive operational and tactical sketches of items such as rendezvous points

13-51. For how many minutes before the beginning of a facsimile schedule should a station (a) make a preliminary test call, and (b) transmit the synchronous signal?
1. Both (a) and (b), 2 min
2. (a) 2 min, (b) 5 min
3. (a) 5 min, (b) 2 min
4. Both (a) and (b), 5 min

Learning Objective: Identify the primary means of delivering traffic to ships, and describe various ship/shore circuits and procedures.

13-52. What is the primary means of delivering traffic to ships?
1. Fleet Multichannel Broadcast System
2. VERDIN
3. Composite Fleet/General Broadcast
4. Merchant Ship Broadcast

13-53. What is the primary means of ship/shore communications today?
1. CW
2. Radioteletype
3. Single sideband reduced carrier
4. Single sideband suppressed carrier

13-54. What are ORESTES circuits?
1. Fully duplex nonsecure ship/shore radioteletype circuits over which traffic may be processed very rapidly
2. Secure ship/shore radioteletype circuits which may be operated in simplex or semiduplex modes of operation only
3. Secure ship/shore radioteletype circuits which may be operated in simplex, semiduplex, or fully duplex mode
4. Radiotelephone circuits for ship/shore use

13-55. The Federal Communications Act of 1934 provides for what penalty for those found guilty of transmitting obscene, indecent, or profane language by radio?
1. Not more than $5,000 fine or one year's imprisonment, or both
2. Not more than $5,000 fine or two years' imprisonment, or both
3. Not more than $10,000 fine or one year's imprisonment, or both
4. Not more than $10,000 fine or two years' imprisonment, or both

13-56. If a unit observes for the first time a certain deviation from prescribed procedure, which of the following actions should it take?
1. It should send a Communication Improvement Memorandum (CIM) to the violator
2. It should send a CIM to the fleet commander-in-chief, with a copy to the violator
3. It should send a speedletter report to the violator
4. It should send a speedletter report to the fleet commander-in-chief, with copies to COMNAVTELCOM, the type commander, and the violator

---

Learning Objective: State the highest degree of classification that may be processed over RFCS circuitry, and describe the basic equipment that is a part of this system.

13-57. What is the highest security marking of traffic which can be cleared for transmission on a full duplex FSK ship/shore/ship radio frequency carrier shift (RFCS) system covered by a TSEC/KW-7CR?
1. Unclassified
2. Confidential
3. Secret
4. Top Secret

13-58. To learn the operation of each equipment used in the primary ship/shore system, where should you look?
1. NTP 3, Annex C
2. NTP 4, Annex D
3. The operator's section of each equipment technical manual
4. ACP 149, Annex C

13-59. Depending upon the type of transmitter used in conjunction with RFCS, the transmitter frequency must be set to either the exact carrier frequency or to a frequency that is
1. 2 Hz below the carrier frequency
2. 2 Hz above the carrier frequency
3. 2 kHz below the carrier frequency
4. 2 kHz above the carrier frequency

● Questions 13-60 through 13-62, pertaining to full duplex FSK ship/shore/ship (RFCS) equipment, are to be judged True or False.

13-60. The basically crystal-controlled R-1051 receiver, capable of receiving radio signals in the 2 to 30 MHz frequency range, is the primary receiver now used for ship/shore communications.

13-61. For space diversity reception, two receivers are tuned to the same carrier frequency, but their antennas are physically located some distance apart; for frequency diversity reception, two receivers are tuned to different carrier frequencies that are carrying identical information.

13-62. The TSEC/KW-7CR crypto equipment is a duplex device which can be used to send on one channel and receive on the other channel at the same time.

13-63. In the ORESTES system, a restart at the beginning of a crypto day can be made very quickly and easily. How is this done?
1. By replacing the old card in the card reader with a new one
2. By pressing a button and holding it in while turning the knob above the button counterclockwise
3. By inputting a prepared restart program on paper tape
4. By inputting the letters "RST" and the date and time by means of the keyboard

---

Learning Objective: State the number of key cards in a book and the time limit for key card destruction.

13-64. How many ship/shore key cards come in a complete book?
1. 15
2. 21
3. 31
4. 34

13-65. Within how many hours after being superseded must a key card be destroyed?
1. 24
2. 48
3. 72
4. 96

Learning Objective: Discuss traffic flow on primary and secondary ship/shore circuits.

13-66. Which of the following actions occurs when a message arriving at a NAVCOMPARS-equipped station has an error in the critical format line?
1. A time delay occurs at the NAVCOMPARS-equipped station because of required manual intervention and service action
2. A service message will automatically be generated to the sender, advising that, because of an error, the message is rejected and should be retransmitted in correct form
3. A service message, automatically sent to the originator, causes the bell to ring, and directs the retransmission, in correct form, of a specified portion of the message
4. The error will not be detected as it passes through the NAVCOMPARS-equipped station; however, the existing error may trigger other errors, or the message may be missent

13-67. Which of the following types of circuits is the secondary ship/shore circuit?
1. Radiotelephone
2. CW
3. Rad[illegible]letype classified
4. Rad[illegible]e unclassified

13-68. How, if in any way, would it be permissible for a classified message to be sent on the secondary ship/shore circuit?
1. In any way, as this is a secure circuit
2. By first encrypting it off-line
3. By preceding it with the classified material preparatory operating signals
4. In no way

13-69. Briefly, what are (a) the operating principle and (b) the purpose of MIDDLEMAN?
1. (a) An operator in an aircraft copies ships' transmissions on UHF and retransmits them on HF, (b) to permit message traffic to continue without violating EMCON restrictions
2. (a) An operator in an aircraft copies ships' transmissions on UHF and retransmits them on HF, (b) to increase the transmission range
3. (a) An operator in an aircraft copies ships' transmissions on HF and retransmits them on UHF, (b) to increase the transmission range
4. (a) An operator in an aircraft copies ships' transmissions on HF and retransmits them on UHF, (b) to permit message traffic to continue without violating EMCON restrictions

---

Learning Objective: Describe AUTOCAT and MIDDLEMAN operations, procedures for use when the shipboard HF must be shut down, and procedures used in the Pigeon Post system.

13-70. What is the difference between MIDDLEMAN and AUTOCAT?
1. MIDDLEMAN uses an aircraft in its retransmission procedure; AUTOCAT uses a ship
2. The procedure is the same; but the frequencies are different
3. In MIDDLEMAN operations, an operator copies and retransmits; in AUTOCAT operations, the equipment receives and retransmits automatically
4. Retransmissions via MIDDLEMAN are at the same speed as the original transmission; retransmissions via AUTOCAT are at a higher speed

13-71. If the HF transmitters on a carrier must be shut down when, for instance, aircraft are being armed, how, if in any way, can ship/shore communications be maintained?
1. Message traffic may be passed by Pigeon Post, but in no other way
2. After a service message of notification to the NAVCOMMSTA is sent, the operator may send and receive traffic by UHF
3. The operator may transmit via UHF to a relay ship that will then relay the message via HF to a NAVCOMMSTA
4. In no way

13-72. What is the procedure involved in Pigeon Post?

1. An operator physically carries the messages to be sent and goes to another ship to send them
2. Messages and other material are flown from one ship to another, but the operators remain aboard their own ships
3. Messages are prepared on precut tapes, bagged, and flown to a message center for transmission
4. A temporary communications shelter is set up ashore for use while the ship is in that port

Assignment 14

Fleet Communications (Continued): Distress Communications

Textbook Assignment: Pages 338 - 355

Learning Objective: Describe the Fleet Flash Net (FFN) and related procedures.

14-1. What is the Fleet Flash Net (FFN)?
1. A duplex TSEC/KW-7CR covered Top Secret net, the main purpose of which is to provide communications among operational command subscribers
2. An uncovered net which has preemption capabilities over other nets, and which is used only for destructive weather flashes or other similar warnings in which rapid transmission is crucial
3. A duplex net, secure up to Secret only, used primarily for tactical purposes during actual or simulated encounters with hostile forces
4. An uncovered net over which a subscriber may "ring up" the subscriber of his choice by the use of "touchtone" buttons

14-2. Normally, of what precedence(s) are messages transmitted on the FFN?
1. ROUTINE and PRIORITY
2. PRIORITY and IMMEDIATE
3. IMMEDIATE and FLASH
4. FLASH only

14-3. For messages on the FFN, what is the maximum number of (a) addressees, and (b) groups?
1. (a) 12, (b) 100
2. (a) 12, (b) 150
3. (a) 15, (b) 100
4. (a) 15, (b) 150

14-4. What is the meaning of the term "hubbing"?
1. Routing the signal of the calling party through all subscribers of the net and back to the calling party
2. Gaining access to a circuit already in use, and causing interference with the ongoing transmission by testing or transmitting
3. Batching messages for transmission rather than sending them individually
4. Calling in and identifying on the net in order to ensure that all subscribers are accounted for and able to copy

Learning Objective: Describe the Interim Command Switchboard (ICSB), its purpose, and general operating procedures.

14-5. Detailed information concerning the FFN is in NAVTELCOMINST C2303.6 (series). Your textbook tells you that which of the following publications also contains information on that subject?
1. ATP 121
2. ATP 122
3. NTP 3
4. NTP 4

14-6. What is the Interim Command Switchboard (ICSB)?
1. A fully automated interface between voice radio circuits and telephone lines ashore
2. A manually operated interface among subscribers at sea (ships)
3. A fully automated ship/air and air/ship interface
4. A manually operated interface between voice radio circuits and telephone lines ashore

14-7. What is the main purpose of the ICSB?
1. To provide the tactical linkage necessary among the captains of different ships at sea
2. To facilitate the inter-unit communication necessary during search and rescue operations
3. To provide the linkage necessary to enable naval commanders to communicate with their subordinates
4. To provide the linkage necessary in case of medical, fire, or destructive weather emergency

14-8. What types of communications are allowed on ICSB?
1. Official business calls, up to and including Secret
2. Unclassified official and personal calls, with the official having precedence over the personal
3. Unclassified official calls only
4. Official business calls, unclassified and Confidential only

14-9. If a fleet or airborne subscriber attempts to place, through ICSB, an official unclassified call that involves tolls, which of the following actions would normally be taken?
1. The call would be completed, and the NAVCOMMSTA transferring the call would pay the tolls, using operations funds
2. The call would be completed, and the originating subscriber would pay the tolls
3. The call would be completed, and the tolls would be cancelled, by agreement between the government and the telephone companies
4. The call would not be completed

14-10. Frequencies for use in the ICSB network are assigned by
1. the cognizant NAVCAMS
2. the cognizant numbered fleet commander
3. the cognizant Fleet Commander-in-Chief
4. CNO

Learning Objective: Identify the source of control over the HICOM network and its components, identify the frequency of the Fleet Warning/Tactical Net, and describe HICOM and Fleet Warning/Tactical Net operations.

14-11. Who has direct control over the entire HICOM network?
1. The Secretary of Defense
2. The Chief of Naval Operations
3. The Director of the Defense Communications Agency
4. The Commander, Naval Communications Command

14-12. Into how many area voice nets is HICOM divided?
1. One
2. Two
3. Three
4. Four

14-13. Units in which of the following categories may be designated to maintain a continuous guard on the HICOM network?
1. Aircraft carriers and command ships
2. Cruisers and command ships
3. Command ships only
4. All of the above

14-14. Which of the following statements concerning the relationship of naval ships with HICOM is correct?
1. All naval ships, stations, and aircraft are automatically members of the HICOM net
2. All naval ships, stations, and aircraft should be prepared to communicate via HICOM, as they may be directed to do so
3. All naval ships and stations should be prepared to communicate via HICOM if directed to do so, but aircraft are exempt from this requirement
4. As membership in the net is highly restrictive, and the operating frequencies associated with HICOM are classified, no unit should be concerned with operating procedures or equipment unless it is a permanent member of the net

14-15. What is the prescribed procedure for tuning transmitters assigned to HICOM net use?
1. Transmitters should be pretuned and calibrated in a dummy load, and the final tuning accomplished during live transmissions, as tuning is not permitted on HICOM frequencies
2. Each net member is assigned a certain block of time each day in which to tune the transmitter on HICOM frequencies
3. Each net member is assigned a certain block of time each week in which to tune the transmitter on the HICOM frequencies
4. All net members may tune transmitters on HICOM frequencies between 2000 and 0600 local time on a not-to-interfere-with-traffic basis

14-16. The HICOM net may be used for messages of which of the following precedences and classification categories?
1. All precedences and classification categories
2. FLASH or IMMEDIATE in any classification category only
3. All precedences of unclassified messages only
4. FLASH or IMMEDIATE unclassified messages only

14-17. What is the frequency of the Fleet Warning/Tactical Net?
1. 500 kHz
2. 121.5 MHz
3. 277.8 MHz
4. 282.8 MHz

Learning Objective: Identify the two basic types of terminations, and describe procedures and circuits involved in single-channel and variable frequency carrier telegraph (VFCT) terminations.

14-18. As given in your textbook, what are the two basic types of terminations?
1. Complete and partial
2. Temporary and permanent
3. AM and FM radiotelephone
4. Single channel and multichannel radioteletype

14-19. Under normal conditions, (a) where should a termination request be sent, and (b) at least how many hours before the requested time of termination should the request be made?
1. (a) To CNO, (b) 36
2. (a) To the appropriate fleet commander, (b) 36
3. (a) To CNO, (b) 48
4. (a) To the appropriate NAVCAMS, (b) 48

14-20. In what publication are procedures for requesting a termination outlined?
1. NTP 3
2. NTP 4
3. ACP 121
4. ACP 122

14-21. If the signal of a transmitting unit is NOT at traffic quality, which of the following has the responsibility for initiating or requesting frequency shift?
1. The receiving unit
2. The transmitting unit
3. The appropriate NAVCOMMSTA
4. The local security group

14-22. What is the difference, if any, between the operating procedure on a ship/shore circuit and that on a full termination net?
1. On a ship/shore circuit, the sending station must transmit the calls of the receiving and the sending units three times; on a full termination circuit, only one time
2. Messages sent on a ship/shore circuit are limited to 25 words each; on full termination there is no limit
3. On a ship/shore circuit, as opposed to a full termination net, units must wait their turns to transmit
4. There is no difference in procedure; only in frequency

● Questions 14-23 and 14-24, relative to terminations, are to be judged True or False.

14-23. When variable frequency carrier telegraph (VFCT) is used, the signals from the various teletypewriters (channels) are multiplexed together into a "tone package" at the transmitting station for transmission. Then, at the receiving station, the signals are demultiplexed into individual signals and distributed.

14-24. A single channel full period termination circuit on board ship is covered by TSEC/KW-7CR cryptographic equipment.

14-25. State the number and assigned functions of the teletypewriter(s) in a single channel, full period termination.
1. One; used for both transmitting and receiving
2. Two; one for transmitting and one for receiving
3. Three; one for transmitting, and two for receiving
4. Two; each for both transmitting and receiving

14-26. Which of the following statements is correct concerning the tone channels of a division multiplexing teletype terminal?
1. There are two tone channels set and stabilized at 500-Hz separation
2. There are four groups of tone channels, each group containing three channels tuned to the identical frequency, and each group slightly displaced in frequency from the others
3. There are six pairs of tone channels, each pair containing two channels tuned to the identical frequency, and each pair slightly displaced in frequency from the others
4. There are a number of tone channels, each slightly displaced in frequency

14-27. If a ship has been requested to stop sending (QRT) because its transmissions are garbled, what should the operator do?
1. He should immediately shut down and turn off all transmitters
2. He should alternate five minutes transmitting, five minutes silence
3. He should type "RYRY..." on the keyboard until the circuit is restored
4. He should begin sending a test tape

14-28. Ships maintaining a full period termination must send a report at 0001Z daily (unless otherwise directed) concerning circuit outages during the previous radio day. What are (a) the name and (b) the precedence of the report?
1. (a) COMMSTAT, (b) PRIORITY
2. (a) COMMSTAT, (b) IMMEDIATE
3. (a) COMMSPOT, (b) PRIORITY
4. (a) COMMSPOT, (b) IMMEDIATE

Learning Objective: Explain the meanings of the characters that comprise the radio emission designator.

Questions 14-29 through 14-32 relate to the characters that comprise the radio emission designator "3A3J." To answer these questions, select from column B the character which gives the information specified in column A.

	A. Information	B. Characters
14-29.	Type of transmission (Telephony)	1. 3 (1st character)
		2. A (2nd character)
14-30.	Supplementary information (Single sideband suppressed carrier)	3. 3 (3rd character)
		4. J (4th character)
14-31.	Type of modulation (AM)	
14-32.	Necessary bandwidth (in kHz)	

Learning Objective: Explain procedures and regulations regarding transmitter tuning, and state the frequency range of satellite communications.

14-33. When you tune a transmitter, the final stage of which will be tuned on the air, you should ensure that the antenna is grounded, and then follow which of the procedures listed below?
1. First, tune the antenna stage, using average operating power; then, using reduced power, tune the transmitter through all the remaining stages, beginning at the first stage
2. First, tune the transmitter through all the stages preceding the antenna stage; then, in three separate tests -- at low power, average power, and high power -- test the antenna
3. First, tune the transmitter through all the stages preceding the antenna stage; then test the antenna at low power only
4. First, tune the antenna stage, using low power; then, still using low power, tune the transmitter through all the remaining stages, beginning at the first stage

14-34. Normally, when should antennas for frequencies (a) between 15 and 30 MHz, and (b) in the VHF and UHF range be tuned?
1. (a) After darkness, (b) during daylight hours
2. Both (a) and (b), after darkness
3. (a) During daylight hours, (b) after darkness
4. Both (a) and (b), during daylight hours

14-35. What is the maximum allowable time interval between frequency meter checks of the frequency of radio receivers (unless crystal controlled) on circuits with NO or few transmissions?
1. Every hour
2. Every two hours
3. Every three hours
4. Every four hours

14-36. What is the maximum allowable time interval between checks of the shipboard frequency meters against the standard frequency broadcast?
1. Three days
2. One week
3. Fifteen days
4. One month

14-37. When a ship is in port, who will control any transmissions made for test purposes?
1. The communications operators
2. The communications officer
3. The senior officer present
4. The senior enlisted communications person present

14-38. In what frequency bands do Navy tactical and strategic satellite communications operate?
1. SHF and EHF
2. UHF and SHF
3. VHF and UHF
4. HF and VHF

Learning Objective: Identify the location of information on the subjects of communications reports and procedures.

To answer questions 14-39 through 14-42, select from column B the publication which contains the information listed in column A.

A. Information

14-39. Examples of COMMSTAT and COMSPOT reports

14-40. Detailed information concerning the submission of the frequency report

14-41. Formulas for finding bandwidth

14-42. Specific operation procedures concerning various satellites

B. Publications

1. Annex A to NTP 6
2. NTP 2
3. NTP 4
4. OPNAVINST 2400.7

Learning Objective: Identify the frequencies to be used and describe the correct procedures for sending a distress message.

14-43. If a ship sailing alone becomes involved in a distress situation under circumstances in which security considerations outweigh the need for assistance, what frequency(ies) is/are an operator authorized to use to send a distress message?
1. Normal operating encrypted circuits only
2. Normal operating encrypted circuits and national distress frequencies only
3. Normal operating encrypted circuits and international distress frequencies only
4. Normal operating encrypted circuits and national and international distress frequencies

14-44. What frequency(ies) is/are an operator authorized to use to send a distress message if the need for assistance outweighs security considerations?
1. Normal operating encrypted circuits only
2. Normal operating encrypted circuits and national distress frequencies only
3. Normal operating encrypted circuits and international distress frequencies only
4. Normal operating encrypted circuits and national and international distress frequencies

14-45. A distressed ship traveling in company with other ships should transmit a distress message addressed to
1. CQ (all stations)
2. the Officer in Tactical Command (OTC)
3. the nearest ship
4. the appropriate NAVCOMMSTA

Learning Objective: Identify various emergency and calling frequencies and describe the observance of silent periods.

To answer questions 14-46 through 14-48, select from column B the frequency that matches the description of distress or emergency usage given in column A.

	A. Usage	B. Frequencies
14-46.	International voice distress, safety, and calling	1. 500 kHz 2. 1000 kHz 3. 2182 kHz
14-47.	International CW/MCW distress and calling	4. 8364 kHz
14-48.	International CW/MCW lifeboat, liferaft, and survival craft	

To answer questions 14-49 through 14-51, select from column B the frequency that matches the description of distress or emergency usage given in column A.

	A. Usage	B. Frequencies
14-49.	Joint/combined military voice aeronautical emergency and international survival craft	1. 8364 kHz 2. 121.5 MHz 3. 156.8 MHz
14-50.	FM United States voice distress and international voice safety and calling	4. 243.0 MHz
14-51.	International voice aeronautical emergency	

14-52. On what frequency should merchant ships make contact with each other?
1. 318 kHz
2. 500 kHz
3. One of the standard frequencies reserved for merchant ship message traffic
4. The "merchant ship frequency of the day" as designated daily by the cognizant NAVCOMMSTA

To answer questions 14-53 through 14-55, select from column B the frequency that matches the description of search and rescue (SAR) usage given in column A.

	A. Usage	B. Frequencies
14-53.	An international SAR frequency used by mobile units at a search site; also used by shore stations to communicate with aircraft proceeding to or from the search site. CW or voice	1. 3023.5 kHz 2. 4550 kHz 3. 123.1 MHz 4. 138.78 MHz
14-54.	International worldwide voice search and rescue use	
14-55.	U.S. military voice SAR on-the-scene use. Also used for direction finding	

Learning Objective: Discuss the control of distress message traffic and procedures involving the imposition of silence due to a distress situation.

14-56. Through the International Telecommunications Union (ITU) regions of the world, regular periods of silence are observed on and immediately adjacent to the international distress frequency (a) beginning how many minutes before and after each hour, and (b) for how many minutes?
1. (a) 10, (b) 2
2. (a) 10, (b) 3
3. (a) 15, (b) 2
4. (a) 15, (b) 3

14-57. It is required that how many kHz on each side of the international distress frequency be kept clear during silent periods?
1. 10 kHz
2. 20 kHz
3. 30 kHz
4. 50 kHz

14-58. What station is responsible for the control of distress message traffic when it (a) does, (b) does NOT involve civil aviation?
1. (a) The station in distress, but it may be delegated to another station on frequency, (b) the station addressed
2. (a) The station addressed, (b) the station in distress, but it may be delegated to another station on frequency
3. Both (a) and (b), the station addressed
4. Both (a) and (b), the station in distress, but it may be delegated to another station on frequency

14-59. What is the correct form of a CW distress signal to impose silence?
1. CW SOS
2. CW MAYDAY
3. QRT SOS
4. QRT MAYDAY

14-60. What is the correct form of a voice distress signal to impose silence?
1. SILENCE - MAYDAY
2. CLEAR CIRCUIT - SOS
3. CLEAR CIRCUIT - MAYDAY
4. STOP TRANSMITTING - MAYDAY

Learning Objective: Give the correct name of the transmission that precedes a distress call, describe action to be taken by a station hearing a distress call, and describe the setting of the radio upon ship abandonment or when disaster is imminent.

14-61. What is the correct name for a transmission that precedes a distress call and consists of a series of dashes (CW) or two sinusoidal tones (voice transmission)?
1. Alarm signal
2. Distress signal
3. Area alert
4. Distress alert

14-62. If a station which is sending traffic hears a distress call, what action must it take immediately?
1. Turning off its transmitter and receiver in order not to interfere with the emergency transmission
2. Changing frequency (QSY) and continuing to send traffic
3. Calling the station sending the distress message and asking the nature of the distress, location of the unit, and other particulars
4. Stopping the transmitter, staying on frequency, and listening

14-63. Immediately before a ship/aircraft in distress is abandoned or an aircraft is crash-landed, in what condition should the radio equipment be placed?
1. Continuous emission
2. Intermittent emission
3. Power attached, but no emission
4. Equipment off and unplugged

Learning Objective: Describe correct procedures related to acknowledging the receipt of distress traffic, and describe the contents of the follow-up transmission.

● Questions 14-64 through 14-66, relating to acknowledging receipt of a distress message, are to be judged True or False.

14-64. A mobile station receiving a distress message from a nearby mobile station must acknowledge receipt immediately, assuming proper equipment is present and NO restrictions are imposed.

14-65. A mobile station receiving a distress message from a mobile station not in its vicinity must acknowledge immediately.

14-66. A mobile station, aware of an unacknowledged distress signal but NOT able to render assistance, may transmit a distress signal for the station in distress if conditions warrant.

14-67. Which of the following transmissions portrays the correct format for the CW acknowledgement of the receipt of a distress message?

1. WATER WATER WATER DE FIRE FIRE FIRE RRR SOS AR
2. WATER WATER WATER DE FIRE FIRE FIRE RRR RRR RRR SOS SOS SOS AR
3. WATER DE FIRE RRR RRR RRR SOS AR
4. WATER DE FIRE RRR RRR RRR SOS SOS SOS AR

14-68. Which of the following transmissions portrays a correct format for the voice acknowledgement of the receipt of a distress message?

1. WATER WATER WATER THIS IS FIRE FIRE FIRE RECEIVED MAYDAY OUT
2. WATER WATER WATER THIS IS FIRE FIRE FIRE ROMEO MAYDAY OUT
3. WATER THIS IS FIRE RECEIVED MAYDAY OUT
4. WATER WATER WATER THIS IS FIRE FIRE FIRE ROMEO ROMEO ROMEO MAYDAY OVER

14-69. What information must a mobile station which has received a distress message give in a follow-up message, and in what sequence?

1. Its own identification; the time it received the distress message; the approximate time it will reach the station in distress only
2. Its own identification; the time it received the distress message; its own position; its speed; the approximate time it will reach the station in distress
3. Its own identification; its own position; its speed; the approximate time it will take to reach the station in distress; and the true bearings of the unit in distress, if available, when the position seems doubtful
4. Its own identification; its own position; the time it received the distress message; its speed; the approximate time it will take to reach the distressed station; the true bearing of the distressed station, if available when [illegible] position seems doubtful

---

Learning Objective: Describe the format of transmissions for cessation of distress traffic.

14-70. What is the correct format for the CW transmission for cessation of distress traffic?

1. CQ CQ CQ DE NEDO END SOS USS AUSTIN NEDO QUM AR
2. SOS CQ DE NEDO 1615Z USS AUSTIN NEDO QUM AR
3. SOS CQ CQ CQ DE NEDO 1615Z USS AUSTIN NEDO QUM AR
4. SOS CQ CQ CQ DE NEDO NEDO NEDO QUM AR

14-71. Which of the following examples is in a correct format for the voice transmission for cessation of distress traffic?

1. MAYDAY HELLO ALL STATIONS HELLO ALL STATIONS HELLO ALL STATIONS THIS IS FOXFIRE 1615Z BLUEJAY DISTRESS TRAFFIC ENDED OUT
2. MAYDAY CHARLIE QUEBEC THIS IS FOXFIRE 1615Z BLUEJAY DISTRESS TRAFFIC ENDED OUT
3. HELLO ALL STATIONS HELLO ALL STATIONS THIS IS FOXFIRE 1615Z BLUEJAY MAYDAY DISTRESS TRAFFIC ENDED OUT
4. CHARLIE QUEBEC CHARLIE QUEBEC CHARLIE QUEBEC THIS IS FOXFIRE 1615Z BLUEJAY MAYDAY DISTRESS TRAFFIC ENDED OUT

Learning Objective: Describe the composition of and procedures involved with urgency and safety signals. (This objective is continued in Assignment 15.)

14-72. What is the CW urgency signal?

1. QQQ QQQ QQQ
2. UUU UUU UUU
3. XXX XXX XXX
4. ZZZ ZZZ ZZZ

14-73. What is the voice equivalent for the urgency signal?

1. DART DART DART
2. PAN PAN PAN
3. QUEBEC QUEBEC QUEBEC
4. UNIFORM UNIFORM UNIFORM

14-74. If an operator of a mobile station hears an urgency signal as he is preparing to transmit, what procedure should he follow immediately?

1. Changing to another frequency and sending his traffic
2. Listening on the same frequency for at least three minutes
3. Sending the following transmission: "QRZ QRZ QRZ DE (call sign) (call sign) (call sign) K"
4. Contacting shore station and reporting the signal

14-75. What is the CW safety signal?
1. CCC CCC CCC
2. MMM MMM MMM
3. SSS SSS SSS
4. TTT TTT TTT

Assignment 15

Distress Communications (Continued); Commercial Traffic

Textbook Assignment; Pages 355 - 377

Learning Objective: (Continued) Describe the composition of and procedures involved with urgency and safety signals.

15-1. What is the voice safety signal?
1. VENUS VENUS VENUS
2. METRO METRO METRO
3. SURETE SURETE SURETE
4. SECURITE SECURITE SECURITE

15-2. Which of the following types of message should be preceded by a safety signal?
1. One that concerns navigation safety or gives a meteorological warning
2. One that warns of possible impending collision with another mobile unit
3. One that warns of mines in the area
4. One that reports the sighting of a hostile unit

To answer questions 15-3 through 15-5, select from column B the distress signal used by merchant ships to indicate the class of distress shown in column A.

	A. Classes of Distress	B. Distress Signals
15-3.	Armed merchant ship raids	1. AAAA
		2. MMMM
15-4.	Aircraft	3. QQQQ
15-5.	Mine	4. RRRR

To answer questions 15-6 and 15-7, select from column B the distress signal used by merchant ships to indicate the class of distress shown in column A.

	A. Classes of Distress	B. Distress Signals
15-6.	Warship raider	1. RRRR
15-7.	Submarine	2. SSSS
		3. WWWW
		4. XXXX

Learning Objective: Describe the requirements for distress watches ashore.

15-8. A NAVCOMMSTA that is open to public correspondence must maintain, as a minimum, a continuous watch on what frequency?
1. 500 kHz
2. 2182 kHz
3. 3023.5 kHz
4. 123.1 MHz

15-9. All naval air activities with VHF/UHF tower communications capability must guard what two frequencies?
1. 121.5 MHz and 156.8 MHz
2. 121.5 MHz and 243.0 MHz
3. 121.5 MHz and 123.1 MHz
4. 156.8 MHz and 243.0 MHz

Learning Objective: Identify the location of regulations pertaining to commercial traffic handling, and state the policy regarding transmission and delivery of commercial traffic by U.S. naval communications.

15-10. What publication contains detailed coverage of the handling of commercial traffic by the U.S. Navy?
1. NTP 4
2. NTP 6
3. NTP 9
4. NWP 4

15-11. Which of the following statements is correct regarding the transmission and delivery of commercial traffic by U.S. naval communications?
1. All commercial traffic must be transmitted and delivered within 24 hours
2. All commercial traffic must be transmitted and delivered within 36 hours
3. Commercial and official government traffic are transmitted, intermingled, in the sequence in which they are received
4. Within regulations, commercial traffic is handled as rapidly as possible, but official government traffic has priority, and no guarantee is made when (or that) commercial traffic will be transmitted

---

Learning Objective: Explain the method of designation of the commercial traffic clerk and identify his duties.

15-12. (a) By whom, and (b) how should the commercial traffic clerk be designated?
1. (a) By the commanding officer, (b) by oral proclamation and the pinning on of an identification badge
2. (a) By the commanding officer, (b) in writing
3. (a) By the communications officer, (b) by oral proclamation and the pinning on of an identification badge
4. (a) By the communications officer, (b) in writing

15-13. Which of the following duties is NOT listed in your textbook as a duty of the commercial traffic clerk?
1. Keeping a complete file of all incoming and outgoing commercial messages
2. Maintaining and understanding all instructions and materials concerned with handling commercial traffic
3. Preparing and posting the communications watch bill
4. Collecting proper charges and safeguarding funds collected and in his custody

15-14. To whom should the commercial traffic clerk forward for review the prescribed reports he prepares?
1. The communications officer
2. The administration officer
3. The operations officer
4. The executive officer

Learning Objective: Explain various procedures related to commercial traffic funds.

15-15. Naval commercial traffic funds should be inspected upon relief of the commercial traffic clerk and at what regular time intervals?
1. Every three weeks
2. Every month
3. Every six weeks
4. Every two months

15-16. The regularly scheduled inspections of the naval commercial traffic funds must be conducted by whom?
1. The communications officer and an officer he selects
2. The officer of the day and the senior enlisted man in the communications department
3. Two officers or senior enlisted personnel, one of whom must be the communications officer
4. Two officers or senior enlisted personnel, one of whom should be from the supply department, if possible

15-17. If NO irregularities are found during the inspection of commercial funds, what is the minimum length of time for which the report must be retained?
1. 60 days
2. 90 days
3. Six months
4. One year

15-18. If there are irregularities disclosed during the inspection of commercial funds, to what destination must a report, accompanied by endorsements, be sent?
1. Navy Regional Finance Center
2. Director of Naval Communications
3. Federal Communication Commission
4. Naval Telecommunications Command

15-19. What is the maximum amount of commercial traffic funds allowed to accumulate in the custody of the commercial traffic clerk without special approval by COMNAVTELCOM?
1. $50
2. $75
3. $100
4. $150

15-20. When the time for remittance arrives, in what form should deposited funds be made available to the commercial traffic clerk?
1. Cash
2. U.S. Treasury check
3. Postal Money Orders
4. Credit vouchers

15-21. Which of the following fees are listed in your textbook as authorized expenditures from naval commercial traffic funds?
1. Money order fees, required registration fees, typewriter and teletype ribbons
2. Money order fees, required postage for mailing reports, pencils and standard forms for communications
3. Money order fees, required postage for mailing reports, required registration fees for registered mail
4. Required postage for mailing reports, required postage for mailing Home Town News Release forms to home towns of personnel, required registration and insurance fees for registered mail

15-22. For which of the following reasons may a refund be made to a person sending a non-Government message?
1. Addressee deceased
2. Addressee unknown
3. Addressee moved
4. Ship out of range

15-23. How often should reports of commercial traffic be prepared and submitted, assuming that commercial traffic has been handled?
1. Weekly
2. Biweekly
3. Monthly
4. Quarterly

Learning Objective: Explain serial number assignment and report symbol placement and name the reference which contains instructions for word count.

15-24. If a Class D message, entitled to Class E privilege, bears the serial number "SRS 14C," what would be the serial number of a second unpaid service message on it?
1. SRS 14CB
2. SRS 14C(2)
3. SRS (next available number)C
4. SRS 14C(SVC2)

15-25. A message, assigned serial number SRS 12D by the first station by which it is transmitted, would be assigned what serial number, if known, by the second transmitting station?
1. SRS 12D
2. SRS 12DA
3. SRS 12D-1
4. Unknown. The second station assigns a number in sequence with the list of that station

15-26. Where should report symbols (such as NAVCOMPT 7210-1) be placed when a commercial traffic report is filed?
1. On a log in the unit
2. On the envelope or cover only
3. On the abstract form only
4. On both the envelope or cover and abstract form

15-27. The Navy uses two systems of word count, domestic and international. Where can you find details on these two systems?
1. NTP 4
2. NTP 6
3. NTP 9
4. NWP 4

Learning Objective: Define Classes A and B messages, and explain the system of handling abstracting, and accounting for messages of these classes which require commercial filing or refiling.

15-28. Which of the following descriptions correctly identifies Classes A and B messages?
1. Official U.S. Government messages
2. Toll-free personal messages
3. Personal messages subject to tolls
4. Press releases

15-29. When a Class A or B message originating from or addressed to a person outside the U.S. is filed with a commercial company, to what facility should it ordinarily be sent first for relay?
1. The U.S. military communications facility nearest the point of destination
2. The U.S. military communications facility nearest the point of origin
3. The commercial communications office nearest the point of destination
4. The U.S. Navy Overseas Control Facility in San Diego or Norfolk

15-30. When a message is refiled by a shore station within the continental U.S. and addressed to a point in (a) Canada, (b) Cuba, or (c) the Saint Pierre-Miquelon Islands, should domestic or international form and word count be used?
1. (a) Domestic, (b) international, (c) international
2. (a) International, (b) international, (c) international
3. (a) Domestic, (b) international, (c) domestic
4. (a) Domestic, (b) domestic, (c) international

15-31. When a message is refiled by a shore station outside the continental U.S. and addressed to a point in (a) Hawaii, (b) Canada, or (c) San Diego, should domestic or international form and word count be used?
1. (a) International, (b) international, (c) domestic
2. (a) International, (b) international, (c) international
3. (a) Domestic, (b) international, (c) domestic
4. (a) Domestic, (b) domestic, (c) domestic

15-32. When the point of refile is treated as the point of origin, where in the message, if anywhere, is the point of actual origin shown?
1. After the signature
2. Immediately after the date in the heading
3. In parentheses at the beginning of the first line of text
4. Nowhere

To answer questions 15-33 through 15-35, select from column B the report form on which the report described in column A should be prepared.

	A. Report Descriptions	B. Forms
15-33.	Report of outgoing Classes A and B and official radiotelephone messages from a Navy ship to a commercial shore radio station	1. Speedletter Form 2065 2. NAVCOMPT 2065 3. NAVCOMPT Form 2132
15-34.	Report of incoming Classes A and B messages received by Navy ships from commercial shore stations	
15-35.	Report of Class B messages refiled with commercial communication companies by naval shore stations which are designated commercial refile activities	

15-36. How many copies, if any, of each message reported must be sent with the monthly report of Class B messages refiled by commercial refile activities?
1. One
2. Two
3. Three
4. None

Learning Objective: Define Class D messages, and explain the system of handling, abstracting, and accounting for them.

15-37. Which of the following descriptions correctly identifies Class D messages?
1. Official messages of the Department of Defense
2. Official messages of U.S. Government departments and agencies other than the Department of Defense
3. Non-Government messages subject to tolls
4. Toll-free non-Government messages

15-38. On board U.S. Navy ships, who is responsible for approving Class D messages?
1. The commanding officer or an officer designated by him
2. The executive officer or an officer designated by him
3. The communications officer or an officer designated by him
4. The commercial traffic clerk

15-39. On board U.S. Navy ships, who determines the word count and associated charges for Class D messages?
1. The communications officer
2. The assistant communications officer
3. The fiscal accounting clerk
4. The commercial traffic clerk

15-40. If doubt exists as to the proper charge for the transmission of a Class D message, and the unit is unable to obtain such information by a rate request, what charge, if any, should be collected at the time the message is filed?
1. The maximum charge
2. The minimum charge
3. The charge thought to be correct
4. None

NR3 CK? DL NAVSTA ADAK 12 MAR 78 1103 AMC

DAVID CHRISTOPHER INC

TULSA OKLAHOMA

YOUR RECOMMENDATION IS REQUESTED REGARDING

OPTIMUM THICKNESS OF ALUMINUM FOR PURPOSE

PREVIOUSLY DISCUSSED. S. JERNIGAN

Figure 15A

- In answering question 15-41, refer to figure 15A.

15-41. How many chargeable words or groups are in the preceding Class D message, domestic form?
1. 13
2. 15
3. 20
4. 21

PCH DE NMIB NR4 INTL USS AMERICA/NMIB CK?

12 1350

$\overline{\text{BT}}$ MP $\overline{\text{BT}}$

WAYNE JACOBS

1423 WESTPATRICKST

SANDIEGO

$\overline{\text{BT}}$

SELL HOUSE ON FIREFLYBLVD AT PRICE QUOTED $\overline{\text{BT}}$

SEAN GABRIEL AR NMIB K

Figure 15B

- In answering question 15-42, refer to figure 15B.

15-42. How many chargeable words or groups are in the preceding Class D message, international form?
1. 7
2. 9
3. 14
4. 15

15-43. If the first line of a domestic form message reads "NR4 CK15 DL NAVSTA ADAK 12 MAR 78 1115 AMP," what information is relayed by "AMP"?
1. "A" indicates that this is a Class A message; "M" indicates it was handled by military communications; "P" indicates it is a press release
2. "A" indicates this is a Class A message; "MP" is a service indicator
3. "AM" indicates the message was filed in the morning; "P" indicates this is a paid commercial message
4. "AM" indicates the message was filed in the morning; "P" indicates the time zone is Pacific

- Questions 15-44 and 15-45, on the subject of abstracting Class D messages, are to be judged True or False.

15-44. On a regular basis, ships that collect money for the handling of Class D messages submit checks or money orders made out to the commercial companies involved.

15-45. A unit must report all Class D messages filed with it for which it has received payment for transmission, but need NOT report service messages or Class D messages that it has received over Navy circuits.

15-46. Which of the following examples is in the correct format for reporting ship identification on an abstract of Class D messages?
1. NJFK/USS JOHN F KENNEDY
2. USS JOHN F KENNEDY/NJFK
3. NJFK
4. USS JOHN F KENNEDY

15-47. A message identified by "SVH" at the beginning and end of the preamble has absolute priority of transmission. For what is "SVH" always an identifier?
1. Safety of Life Message
2. Special Vessel Handling Message
3. Submerged Vessel Sighting Report
4. Sinking Vessel Alarm

15-48. Charges for commercial messages are subject to change. What publication (with up-to-date changes) should be consulted for rate information?
1. NTP 4
2. NTP 6
3. NTP 9
4. NWP 4

Learning Objective: Define Class D messages entitled to Class E privilege, and explain the system of handling, abstracting, and accounting for them.

15-49. Which of the following correctly describes a Class D message entitled to Class E privilege?
1. An emergency message filed by the Red Cross
2. A message which, because of the geographical location of its addressee, can not be sent as Class E, although its contents meet the provision of that class
3. An official Government message which is placed ahead of all other Class D messages for earlier transmission
4. A message concerning the health or life of a member of the immediate family of a member of the U.S. Navy

15-50. What symbol is placed as the first word in the text to identify a Class D message entitled to Class E privilege?
1. COMLE
2. QSJ
3. PARLE
4. DPRIE

● Information for question 15-51: A Class D message entitled to Class E privileges was filed aboard ship. It was transmitted to another naval ship which relayed it to a commercial shore station. The message was then delivered by a long-distance call on commercial telephone.

15-51. For what service will the sender be charged?
1. The transmission and relay service of the Navy, the receipt charges of the commercial station, and the long-distance telephone charges
2. The receipt charges of the commercial station and the long-distance telephone charge only
3. The receipt charges of the commercial station only
4. The long-distance telephone charges only

● Information for question 15-52: Included with the monthly report of Class D messages entitled to Class E privileges must be a copy of each message, with an attached QSJ or service message.

15-52. What is the QSJ or service message?
1. A report of delivery
2. A record of the DTG and word count
3. A rate request
4. An authorization for transmission

15-53. Which of the following statements relative to the remittance, if any, which accompanies the abstract is correct?
1. Included should be a check or money order payable to Navy Regional Finance Center
2. Included should be two checks or money orders, one to Western Union Telegraph Company, and one to the applicable telephone company
3. Included should be a check or money order payable to Western Union Telegraph Company only
4. No remittance should accompany this abstract

15-54. Which of the following statements reflects the normal peacetime policy of Navy handling of press releases from correspondents aboard Navy ships at sea?

1. Press releases are processed as quickly as possible after the transmission of all messages filed by naval personnel
2. Operational messages have priority; then, all other messages, including press releases, are sent on a "first-come, first-served" basis
3. Press releases take precedence over all messages except emergency messages (distress, etc.)
4. Press releases take precedence immediately after operational messages

15-55. Which of the following service indicators could properly be used on a press release for which payment has NOT been made, being sent directly to or from a continental U.S. naval station and handled commercially by the Western Union Telegraph Company only?

1. DPR COLLECT
2. DPR
3. PRESSE COLLECT
4. PRESSE DPR COLLECT

15-56. Which of the following statements correctly reflects a procedure that is utilized for collection of tolls for a press release?

1. The commercial charges must be paid in advance, but the Navy charges may be either paid in advance or charged to a newspaper or news association
2. The Navy charges must be paid in advance, but the commercial charges may be either paid in advance or charged to a newspaper or news association
3. The entire toll may be charged, in which case the Navy Regional Finance Center is responsible for collecting the entire toll and making proper remittance to the commercial carriers
4. The entire toll may be charged, in which case the Navy Regional Finance Center is responsible for collecting the Navy tolls, and the commercial carriers are responsible for collecting the commercial tolls

15-57. What letter is added to a serial number to identify the related message as a press release?

1. C
2. M
3. P
4. X

Learning Objective: Explain the system of handling, abstracting, and accounting for Class E messages.

15-58. Which of the following descriptions correctly characterizes Class E messages?

1. They are primarily Government messages related to stores and supplies
2. They are primarily Government messages related to operational tactics
3. They are primarily personal messages sent by naval personnel
4. They are personal messages sent approximately equally from Army, Navy, and Air Force personnel, and, to a lesser degree, from other members of the Armed Forces

15-59. Where are the refile points for Class E messages from and addressed to authorized persons on board ships and at overseas duty stations?

1. San Diego, CA and Washington, DC
2. San Diego, CA and Norfolk, VA
3. Stockton, CA and Washington, DC
4. Stockton, CA and Norfolk, VA

15-60. Why are there charges for some Class E messages and NOT for others?

1. Those sent entirely on Navy circuits are toll-free; others, sent entirely on commercial circuits, have tolls assessed
2. Those sent entirely on Navy circuits are toll-free; others, sent partially on commercial circuits, have tolls assessed for the commercial service
3. This service is free to active-duty Navy personnel; tolls are collected from other users
4. Fees are assessed for sending messages to or from an overseas station; other messages are toll free

15-61. What are the indicators, if any, used to distinguish (a) telegrams, and (b) overnight telegrams?

1. (a) None, (b) NL
2. (a) None, (b) OT
3. (a) T, (b) none
4. (a) T, (b) OT

15-62. The minimum charge is for how many words for (a) a (full-rate) telegram, and (b) an overnight telegram?
1. (a) 8, (b) 75
2. (a) 10, (b) 100
3. (a) 12, (b) 75
4. (a) 15, (b) 100

15-63. Which of the following statements relative to the remittance, if any, which accompanies the Class E message report is correct?
1. Included should be a check or money order payable to Navy Regional Finance Center
2. Included should be two checks or money orders, one to Western Union Telegraph Company, and one to the applicable telephone company
3. Included should be a check or money order payable to Western Union Telegraph Company only
4. No remittance should be included with this report

Learning Objective: Define coastal harbor radiotelephone service and explain procedures relative to its use.

15-64. What is coastal harbor radiotelephone service?
1. A telephone communication service over naval circuits between, and limited to, ships and the operating departments at their home ports
2. A telephone communication service over commercial circuits between, and limited to, coastal naval stations and naval vessels within a few hundred miles of the shore
3. A telephone communication service over naval circuits between, and limited to, coastal naval stations and naval vessels within a few hundred miles of the shore
4. A telephone communication service over commercial circuits between naval vessels within a few hundred miles of the shore and any land-based telephone

15-65. With certain limited exceptions, are harbor radiotelephone calls (a) incoming to or outgoing from the ships, and (b) usually prepaid or collect?
1. (a) Outgoing from the ships, (b) collect
2. (a) Outgoing from the ships, (b) prepaid
3. (a) Incoming to the ships, (b) collect
4. (a) Incoming to the ships, (b) prepaid

15-66. (a) What publication shows the division of coastal waters into rate areas for coastal harbor radiotelephone service, and (b) from whom may rates be requested if assistance is required?
1. (a) NTP 4, (b) the nearest commercial operator
2. (a) NTP 4, (b) the marine operator
3. (a) NTP 9, (b) the nearest commercial operator
4. (a) NTP 9, (b) the marine operator

Learning Objective: Explain procedures relative to the high seas radiotelephone service.

Questions 15-67 through 15-69, relative to high seas radiotelephone service, are to be judged True or False.

15-67. Authorization and availability of high seas radiotelephone service are the same as that of harbor radiotelephone service, but there are some additional limitations (atmospheric, etc.) due to the additional distance involved.

15-68. When high seas radiotelephone is utilized, an approximation of the bearing of the ship to the shore station is furnished.

15-69. Normally, all calls from ships using the high seas radiotelephone service are made prepaid.

15-70. In what publication are operating frequencies and land and ocean rate areas associated with high seas radiotelephone contained?
1. NTP 9
2. NTP 2
3. NTP 3
4. NTP 4

☆ U. S. GOVERNMENT PRINTING OFFICE : 1978 740-215/36

COURSE DISENROLLMENT

All study materials must be returned. On disenrolling, fill out only the upper part of this page and attach it to the inside front cover of the textbook for this course. Mail your study materials to the Naval Education and Training Program Development Center.

PRINT CLEARLY

NAVEDTRA Number	COURSE TITLE
10228-G	NRCC RADIOMAN 3 & 2

Name Last First Middle

Rank/Rate Designator Social Security Number

COURSE COMPLETION

Letters of satisfactory completion are issued only to personnel whose courses are administered by the Naval Education and Training Program Development Center. On completing the course, fill out the lower part of this page and enclose it with your last set of self-scored answer sheets. Be sure mailing addresses are complete. Mail to the Naval Education and Training Program Development Center.

NAME

ZIP CODE

MY SERVICE RECORD IS HELD BY:

10228-G NRCC RADIOMAN 3 & 2

Activity

Address ZIP CODE

Signature of enrollee

PDD Form 111

A FINAL QUESTION: What did you think of this course? Of the text material used with the course? Comments and recommendations received from enrollees have been a major source of course improvement. You and your command are urged to submit your constructive criticisms and your recommendations. This tear-out form letter is provided for your convenience. Typewrite if possible, but legible handwriting is acceptable.

Date ____________________

From: ____________________________________

____

____________________________________ ZIP CODE _________

To: Naval Education and Training Program Development Center (PD9)
Building 942
Pensacola, Florida 32509

Subj: NRCC RADIOMAN 3 & 2, NAVEDTRA 10228-G

1. The following comments are hereby submitted:

(Fold along dotted line and staple or tape)

....

(Fold along dotted line and staple or tape)

....

DEPARTMENT OF THE NAVY

NAVAL EDUCATION AND TRAINING PROGRAM
DEVELOPMENT CENTER (PD 9)
PENSACOLA, FLORIDA 32509

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
DEPARTMENT OF THE NAVY
DOD-316

NAVAL EDUCATION AND TRAINING PROGRAM DEVELOPMENT CENTER (PD 9)
BUILDING 942
PENSACOLA, FLORIDA 32509